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PAPERS AND PROCEEDINGS

OF

The Royal Society of Tasmania

Volume 92

Edited by William Bryden

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1958.

The Royal Society of Tasmania

Volume 92

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The Royal Society of Tasmania

Papers and Proceedings Volume 92

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Royal Society of Tasmania.

Annual Report for the Year 1957.

The Annual Meeting of the Society was held in the Society's rooms, on 5th March, 1957.

The President, His Excellency the Governor of Tasmania (Sir Ronald Cross), presided.

The following office-bearers were elected:—

Vice-President : Under the Society's Rules, Mr. F. C. Wolfhagen retired from the office of Vice-President and Mr. J. W. C. Wyett was appointed to the vacancy.
Hon. Secretary and Librarian : Dr. W. Bryden.
Hon. Treasurer : Mr. G. E. A. Hale.
Hon. Auditor : Mr. A. M. Hewer.
Council : Under Rule 21, Professer S. W. Carey and Mr. L. W. Miller retired as members of the Council, and the Hon. Mr. Justice Crisp and Mr. R. M. H. Garvie were elected in their places for a period of three years.

The Council made the following appointments for the year:—

(*a*) Standing Committee : Mr. J. W. C. Wyett, Dr. W. V. Teniswood, Mr. G. E. A. Hale and the Hon. Secretary (Dr. W. Bryden).
(*b*) Representatives on the Trustees of the Tasmanian Museum and Art Gallery : Professor A. Burn and Mr. G. F. Davies.
(*c*) Representative on the Trustees of the Botanical Gardens : Mr. S. Angel.
(*d*) Representative to the Library Association of Tasmania : Dr. W. Bryden.
(*e*) Representative on the Nomenclature Board : Mr. E. R. Pretyman.

Meetings : Eight ordinary meetings and a special lecture were held during the year in addition to the R. M. Johnston Memorial Lecture. The following lectures were delivered:—

March : "The Land of the Rivers" by Mr. R. M. H. Garvie (illustrated).
April : "Some Impressions of Mexico", by Mr. and Mrs. L. E. Luckman (illustrated).
May 7th : "Artificial Breeding of Dairy Cattle", by Mr. G. K. Meldrum (illustrated).
May 13th : Special lecture by M. Jean Querton, Minister for Belgium in Australia, on "The Belgian Congo" (illustrated by two films).
June : "Control of Flowering", by Professor H. N. Barber (illustrated).
July : The following scientific films were shown:—
"Discovery of a New Pigment" (I.C.I. Ltd.).
"Web of Life", Part I. (U.S. Information Service).
"Atoms for Peace" (U.S. Information Service).
"Foothold on Antarctica" (British Petroleum Ltd.).
August : R. M. Johnston Memorial Lecture (see below).
September : "Electricity in Plants" by Dr. B. I. H. Scott (illustrated).
October : "The Ecology of the New Zealand Scree Plants", by Dr. F. J. F. Fisher (illustrated).
November : "The Milky Way System", by Dr. W. Buscombe (illustrated).

R. M. Johnston Memorial Lecture.—The Council awarded the R. M. Johnston Memorial Medal to Professor Frederick Walker, Professor of Geology, Queen's College, St. Andrews University, Dundee, Scotland. His Excellency Sir Ronald Cross presented the medal, after which Professor Walker delivered the R. M. Johnston Memorial Lecture, his subject being "Underground Phase of Volcanic Activity". The lecture was illustrated.

Miss Jean Beattie.—At the September meeting the Chairman took the opportunity of referring to the valued services rendered to the Society by Miss Jean Beattie over a period of twenty-four years. Miss Beattie was presented with an electric clock and a cheque from a number of the members of the Society.

Joseph Milligan Bequest.—The land at George Town, left to the Society by the late Joseph Milligan, was sold and the money received invested in Government stock. The interest when received will be added to the Milligan Bequest which consists of interest from the investment of the sum received for the sale of land at Bicheno left to the Society by Dr. Milligan and sold some years ago.

Library.—During the year 401 volumes (books and journals) were added to the library in addition to a number of reports and pamphlets from British and foreign institutions and learned societies. The number of institutions on the exchange list is 300. The library now consists of 31,340 volumes.

Membership.—The Society consists of the following financial members:—

Honorary Members			2
Corresponding Members			1
Life Members			33
Ordinary Members—			
	Class A =	247	
	Class B =	180	
			427
Associate Members			20
Total Financial Members			483

During the year forty-two (42) new members were added to the roll while thirty-two (32) names were removed from the lists owing to deaths, resignations, &c.

Northern Branch.—During the year Council has given considerable time to representations made by the Northern Branch concerning finances and some functions of the Society. It is hoped that as a result of these discussions a more satisfactory method may be found to allot necessary finances to both the Northern Branch and the parent Society.

Papers and Proceedings.—Volume 91 of the "Papers and Proceedings" was published and the Society is grateful to the Government of Tasmania for helping to defray the cost of the volume.

Thanks.—The Council records its thanks to Miss E. M. Geddes, Assistant Librarian, for her services to the Society in so many ways. Thanks are extended also to all who have made donations of various kinds during the year.

ROYAL SOCIETY OF TASMANIA.

Statement of Receipts and Payments for Year to 31st December, 1957.

Receipts.

			£ s. d.
Subscriptions—			
1957. 241 @ £2 10s.	£602 10 0		
Less credited in 1956	0 6 0		
		602 4 0	
179 @ £2	358 0 0		
Less credited in 1956	1 0 0		
		357 0 0	
18 @ £1 5s.		22 10 0	
Balances due on 1957 subscriptions paid in 1956		0 14 0	
1956. 4 @ £2	£8 0 0		
2 @ £1 10s.	3 0 0		
		11 0 0	
1958. 1 @ £2 10s.	£2 10 0		
1 @ £2	2 0 0		
		4 10 0	
Subscriptions paid during 1957		997 18 0	
Bank Interest		0 6 3	
Balance brought forward from 1956 ..		42 18 10	
		£1,041 3 1	

Payments.

	£ s. d.	£ s. d.
Salary and Superannuation—		
Salary	800 19 10	
Less amount overdrawn	2 4 8	
	798 15 2	
Less Govt. Grant	475 0 0	
	323 15 2	
Add Superannuation	24 4 0	
		347 19 2
Northern Branch: share of subscriptions for 1956 ..		130 0 10
Equipment	....	70 1 2
Library—		
Journals	139 17 7	
Less Refund from University	10 11 6	
	129 6 1	
Add Books	9 14 9	
		139 0 10
Petty Cash	107 0 0	
Less Refund of postage	0 8 11	
		106 11 1
Telephone	....	10 0 0
Stationery	....	34 15 7
Light and power	....	65 12 9
Insurance	....	25 13 9
Meetings—		
Attendant's wages	27 12 6	
Less Rent for room	21 10 0	
		6 2 6
Films for General Meeting	....	3 6 4
Conversazione	42 6 0	
Less Contr. from Friends of Museum	30 0 0	
		12 6 0
Paint for Royal Society room	....	27 19 4
Transfer to Milligan Memorial Fund	....	3 4 0
Miscellaneous Expenses	....	24 13 10
Balance to next Account	....	33 15 11
		£1,041 3 1

A. M. D. HEWER, *Auditor.*

W. E. L. H. CROWTHER, *Vice-President.*
W. BRYDEN, *Hon. Secretary*
G. E. A. HALE, *Hon. Treasurer.*

Northern Branch.

Annual Report, 1957.

The Annual General Meeting of the Northern Branch of the Royal Society of Tasmania was held at the Queen Victoria Museum on March 29th, 1957, when the following were elected to the Branch Council:—

Vice-Chairman : Mr. G. H. Stancombe (1957).

Past-Chaiman : Mr. R. S. Smith (ex-officio).

Hon. Secretary-Treasurer : Mr. W. F. Ellis (1957).

Members of Council : Mrs. I. J. Mead (1957, 1958); Dr. J. H. Wilson (1957-1958); Mr. J. Lord (1957).

Those continuing in their term of office were:—

Chairman : Mr. G. H. Crawford (1957).

Council Members : Mr. G. H. Willing (1957); Mr. K. R. von Stieglitz (1957).

The decease of Mr. William Hart, late Vice-Chairman of the Branch, was recorded with deep regret.

Activities During 1957

General Meetings.

Twelve meetings were held during the year at which the following papers were read:—

22nd February, 1957 : "The Habitat, Economy and Equipment of the Australian Aborigines", by Mr. F. D. McCarthy, Dip.Anthrop.

29th March, 1957 : "Sarawak—Land of the Hornbill", by Mr. Kenneth Pawson.

3rd May, 1957 : "Bird Banding and Bird Migration", by Mr. Duncan McDonald.

31st May, 1957 : "Early Tasmanian Artists", by Mr. Henry Allport, LL.B.

21st June, 1957 : "Some Surprising New Discoveries about the Earth's Magnetism", by Prof. S. W. Carey, D.Sc.

26th July, 1957 : "Early Growth of Sandy Bay, Hobart", by Miss Amy Rowntree, O.B.E., M.A.

30th August, 1957 : "The Changing Population of Tasmania", by Prof. Peter Scott, M.Sc.(Econ.).

11th September, 1957 : "Editing for the Clyde Company", by Mr. P. L. Brown.

30th September, 1957 : "The Land of the Rivers", by Mr. R. M. H. Garvie, B.Sc., M.I.C.E., M.I.E. Aust.

25th October, 1957 : "The Artificial Satellite", by Dr. B. I. H. Scott, B.Sc., Ph.D.

15th November, 1957 : "Looking at the Stars", by Dr. W. Buscombe, M.A., Ph.D.

29th November, 1957 : "W. B. Gould, Artist and Convict in Van Diemen's Land", by Mrs. I. J. Mead, B.A.

Excursions.

Seven excursions were arranged during the year, all of which were well attended. As in previous years, visits were made to places of historical or scientific interest. The excursions were:—

23rd February, 1957 : East Tamar, led by Rev. E. C. Rowland.

24th March, 1957 : Longford District—"Longford House", "Hythe" and "Woodstock", led by Mr. G. H. Stancombe.

14th April, 1957 : Fingal District—"Cullenwood", "Malahide", "Killymoon", led by Mr. K. R. von Steiglitz.

8th September, 1957 : Goliath Portland Cement Co. Ltd., Railton.

13th October, 1957 : Duck Reach and Trevallyn Power Stations, Launceston.

27th October, 1957 : Waterhouse District Land Development, led by Dr. J. H. Wilson.

24th November, 1957 : Longford District—"Belmont", "Norley", "Pinefield".

Sub-Committees.

Two sub-committees were constituted during the year, the first to consider the means whereby the activities of the Branch may be improved and the second to undertake the assembly of documents and pictures of importance to the study of Tasmanian history and, when possible, to gather photographic copies of original material in private ownership.

Each of the sub-committees made good progress with its allotted task. The work of that concerned with the location and preservation of historical material was particularly fruitful but limited by lack of available funds.

Publications.

The transcription of the micro-film copy of the journals of John Helder Wedge has been almost completed and Mr. G. H. Stancombe has made considerable progress with the compilation of the background notes on Wedge. It is anticipated that the manuscript will be ready for publication in 1958.

The earlier publication "The Penal Settlements of Van Diemen's Land" continues to sell steadily, mainly through bookshops and the Queen Victoria Museum.

Statement of Accounts at 31st December, 1957.

Receipts.	£	s.	d.
Balance at 1.1.57	129	7	5
Subscription share	130	0	10
Bank interest	5	1	6
Sales of publication	10	2	4
	£274	12	1

Expenditure.	£	s.	d.
Lectures	43	14	3
Library	46	10	3
Printing and advertising	24	7	4
Postages and petty cash	43	19	10
Balance carried forward	116	0	5
	£274	12	1

W. F. ELLIS, *Hon. Secretary.*

J. R. FORWARD, *Hon. Auditor.*

SOME TASMANIAN HARVESTMEN OF THE FAMILY TRIAENONYCHIDAE (SUB-ORDER LANIATORES)

By

V. V. Hickman

Ralston Professor of Biology, University of Tasmania

(With 296 Text Figures)

ABSTRACT

Ten genera with thirteen species of harvestmen belonging to the Family Triaenonychidae (Sub-Order Laniatores) have been previously recorded from Tasmania. In the present paper twenty-one new genera and forty-nine new species are described. Of the new species seventeen are placed in genera already established. Some additional information on seven of the previously recorded species is given. The following list includes the new species and those previously recorded from Tasmania. Where additional information on a previously recorded species is given, the name is marked with an asterisk.

Sub-family TRIAENONYCHINAE

Tasmanonyx montanus gen. et sp. n. (79)
Bryonuncia distincta gen. et sp. n. (39)
Pyengadella striata gen. et sp. n. (19)
**Lomanella raniceps* Pocock (100)
**Lomanella atrolutea* Roewer (2)
Lomanella parva Forster
Lomanella exigua sp. n. (19)
Ankylonuncia fallax gen. et sp. n. (10)
Ankylonuncia mestoni gen. et sp. n. (1)
Ankylonuncia barrowensis gen. et sp. n. (7)
Notonuncia diversa gen. et sp. n. (42)
Notonuncia arvensis gen. et sp. n. (11)
Notonuncia obscura gen. et sp. n. (4)
Tasmanonuncia segnis gen. et sp. n. (39)
Leionuncia levis gen. et sp. n. (92)
Allonuncia grandis gen. et sp. n. (12)
Nunciella tasmaniensis sp. n. (94)
Cinuna badia gen. et sp. n. (4)
Cinuna dentata gen. et sp. n. (2)
Nuncioides infrequens gen. et sp. n. (1)
Nuncioides dysmicus gen. et sp. n. (3)
**Paranuncia gigantea* Roewer (111)
Odontonuncia saltuensis gen. et sp. n. (11)
**Callihamus inermis* Roewer (1)
Calliuncus odoratus sp. n. (36)
Calliuncus glaber sp. n. (76)
Nucina silvestris gen. et sp. n. (123)
Nucina dispar gen. et sp. n. (1)
Stylonuncia spinosa gen. et sp. n. (2)
Parattahia u-signata Roewer
Mestonia picra gen. et sp. n. (51)
Mestonia acris gen. et sp. n. (11)
Monacanthobunus tasmanicus Roewer
Monoxyomma silvaticum sp. n. (4)
Monoxyomma cavaticum sp. n. (7)

Sub-family TRIAENOBUNINAE

**Triaenobunus pectinatus* Pocock (= *Peckhamius pectinatus* Roewer) (83)
Triaenobunus asper sp. n. (51)
Triaenobunus inornatus sp. n. (3)
Triaenobunus pilosus sp. n. (3)
Triaenobunus mestoni sp. n. (2)
Triaenobunus montanus sp. n. (3)
Triaenobunus cornutus sp. n. (2)
**Glyptobunus signatus* Roewer (173)
Glyptobunus ornatus sp. n. (11)
Phoxobunus tuberculatus gen. et sp. n. (7)
Phoxobunus rostratus gen. et sp. n. (5)
Eubunus crypsidomus gen. et sp. n. (3)
Allobunus distinctus gen. et sp. n. (3)
Chilobunus spinosus gen. sp. n. (3)
Rhynchobunus arrogans gen. et sp. n. (129)
**Phanerobunus armatus* Roewer (24)
Phanerobunus saxatilis sp. n. (18)
Phanerobunus asperrimus sp. n. (49)
Phanerobunus hebes sp. n. (23)
Miobunus thoracicus Roewer
Miobunus levis sp. n. (4)
Tasmanobunus constans gen. et sp. n. (51)
Tasmanobunus parvus gen. et sp. n. (32)
Chrestobunus spinulatus Roewer
Chrestobunus inermis Roewer
Chrestobunus fuscus sp n.. (95)
Thelbunus mirabilis gen. et sp. n. (6)

Where a number in parentheses follows a name in the above list, it indicates the number of specimens of the particular species that have been examined. Where no number is given, the species has not been recognized amongst those in the collection.

INTRODUCTION

Harvestmen belonging to the family Triaenonychidae have the following features:—Two eyes are present and usually carried on a rounded or conical elevation, which is called the eyemound and situated on the carapace. The eyemound may be smooth and unarmed or armed with a spine or horn of variable form. The dorsal surface of the body is covered by a scutum and three free tergites (not including the anal operculum). The scutum is composed of the carapace fused with the first five abdominal tergites. In some cases the five tergites are evident as five tergal Areas, which are delimited by five transverse grooves, referred to as tergal grooves. In most species the first tergal groove marking the posterior limit of the carapace is quite distinct. It is referred to as the scutal groove or scutal furrow. A pair of three-segmented chelate chelicerae is present at the front of the body. Pedipalpi are robust, stouter than the legs, usually armed with large setigerous spines and end in a strong raptorial claw. The ventral surface of the body is formed mainly by the coxae of the legs, the sternum, the genital operculum and the nine abdominal sternites. The coxae of the first pair of legs are movable, those of the other legs are immovably fused. The sternum is generally long and narrow but in the sub-family Triaenobuninae its posterior end is wide and crescentic. The genital operculum, which is situated immediately behind the sternum is movable. The first abdominal sternite is vestigial, the second and third are fused into the compound sternite bearing the respiratory spiracles, the fourth to the seventh inclusive are free and the eighth and ninth fused into a broad plate in front of the anus.

The legs may be smooth or armed with spines and tubercles. Each metatarsus is usually marked off into a proximal section, the astragalus, and a distal section, the calcaneus, which are immovable on one another. In the males of some species the calcaneus is bent or has a ventral notch. A variable number of segments compose the tarsi of the legs. In the first and second pair of legs the tarsal segments are arranged in two sections, the distal section being referred to as the distitarsus. The first and second tarsi each end in a simple claw; the third and fourth in a three-pronged claw.

Hitherto only 10 genera with 13 species belonging to the family Triaenonychidae have been recorded from Tasmania. However, the State is comparatively rich in species belonging to the family and in the present study 49 new species and 21 new genera are described. The Mount Wellington area, which, because of its ready accessibility, has been searched more thoroughly than other areas, has yielded no less than 19 different species. Harvestmen have been collected in many parts of the State, with the exception of the south-west quarter, and a total of 1797 specimens have been examined.

Most members of the family Triaenonychidae favour cool moist conditions and are found under decaying logs or in moss and leaf-mould in rain forest areas. A few species such as *Triaenobunus pectinatus* Pocock (= *Peckhamius pectinatus* Roewer) and *Phanerobunus armatus* Roewer are more tolerant of less humid surroundings and may be found in such comparatively dry regions as the hills at East Risdon. Some species appear to be confined to one small locality; others, such as *Lomanella raniceps* Pocock, occur in most parts of the State.

Some of the species described in the following pages are of special interest. *Tasmanonyx montanus* sp. n. is one of the most common harvestmen on Mount Wellington and is the only Tasmanian species so far discovered, that has the middle prong of the claws on tarsi III and IV smaller than the lateral prongs. *Bryonuncia distincta* sp. n. and *Pyenganella striata* sp. n. each have the calcaneus of the first pair of legs longer than the astragalus. *Nunciella tasmaniensis* sp. n. is remarkable in that the male has eight instead of only five abdominal tergites fused with the carapace to form the dorsal scutum.

The family Triaenonychidae is usually divided into three sub-families, namely Adaeinae, Triaenonychinae and Triaenobuninae, the form of the sternum being the main distinguishing feature between them. However, from a comprehensive study of New Zealand species Dr Forster (1954, p. 15) has relegated the sub-family Triaenobuninae to the status of a *tribe* in the sub-family Triaenonychinae. This may well be justified after more is known of our Australian species. In the present paper the Triaenobuninae are retained with the original status of a sub-family.

In view of the importance attached to tarsal segmentation in the taxonomy of the Triaenonychidae any variations in the segmentation of tarsi I and II occurring in the one species have been noted. Where a large number of specimens has been examined the variations are shown in tabular form after the systematic description. An interesting feature in a number of species is the marked asymmetry exhibited, especially in the segmentation of tarsi II, the number of segments in the tarsus of the left leg often being different from that in the tarsus of the corresponding right leg. Such variations are indicated in the Tables and text by adding the letter L or R to the number of segments present in the corresponding left and right tarsi. If the specimen is symmetrical and there is no difference in the number of segments on left and right sides, only one number is given.

The two sub-families of the Triaenonychidae represented in Tasmania may be distinguished as follows:—

1. Sternum elongate, narrow and not widely crescentic at the posterior end. Respiratory spiracles usually not concealed by fourth coxae Sub-family Triaenonychinae
2. Sternum short and widely crescentic at the posterior end. Respiratory spiracles usually concealed under bridging granules on fourth coxae .. Sub-family Triaenobuninae

KEY TO TASMANIAN GENERA IN THE SUB-FAMILY TRIAENONYCHINAE

1. Lateral prongs on claws of tarsi III and IV larger than the median prong .... *Tasmanonyx* gen. n.
   Lateral prongs on claws of tarsi III and IV smaller than the median prong 2

2. Calcaneus of leg I longer than astragalus 3
   Calcaneus of leg I shorter than astragalus 4

3. Tarsal formula: 3, 5-6, 4, 4 .... *Bryonuncia* gen. n.
   Tarsal formula: 4, 12-16, 4, 4 .... *Pyenganella* gen. n.

4. Eyemound low and unarmed 5
   Eyemound not so constructed 13

5. Femur and tibia of pedipalp almost unarmed .... *Lomanella* Pocock
   Femur and tibia of pedipalp strongly armed 6

6. Calcaneus of leg I of male notched below 7
   Calcaneus of leg I of male not notched below 8

7. Tarsus II of male with 6-10 segments .... *Ankylonuncia* gen. n.
   Tarsus II of male with 11-18 segments .... *Notonuncia* gen. n.

8. Distitarsus of leg II with three segments 9
   Distitarsus of leg II with more than three segments 10

9. Tarsus I with 3 segments .... *Tasmanonuncia* gen. n.
   Tarsus I with 4-6 segments .... *Leionuncia* gen. n.

10. Eyemound near middle of carapace .... *Allonuncia* gen. n.
    Eyemound near anterior margin 11

11. Tarsus I with 3 segments .... *Nunciella* Roewer.
    Tarsus I with more than 3 segments 12

12. Tarsus I with 4 segments .... *Cinuna* gen. n.
    Tarsus I with 5-6 segments .... *Nuncioides* gen. n.

13. Eyemound conical and unarmed .... *Paranuncia* Roewer.
    Eyemound not so constructed 14

14. Eyemound low and armed above with a small recurved spine .... *Odontonuncia* gen. n.
    Eyemound not so constructed 15

15. Eyemound conical, armed in front with a short spine or hook 16
    Eyemound conical, armed above with a large spine or horn 19

16. Tarsus II with 5 segments .... *Callihamus* Roewer.
    Tarsus II with more than 5 segments 17

17. Front margin of scutum smooth .... *Calliuncus* Roewer.
    Front margin of scutum with denticles or spines 18

18. Front margin with 4 denticles on each side .... *Nucina* gen. n.
    Front margin with 4 spines on each side .... *Stylonuncia* gen. n.

19. Front margin of scutum smooth 20
    Front margin of scutum with denticles 21

20. Tergal Areas I-V smooth .... *Parattahia* Roewer.
    Tergal Areas III-V with blunt tubercles .... *Mestonia* gen. n.

21. Tergal Areas II and III each with a pair of spines .... *Monacanthobunus* Roewer.
    Tergal Area II without spines; Area III with a pair of large spines .... *Monoxyomma* Pocock.

Genus **TASMANONYX** gen. n.

Eyemound subconical, arising from the anterior margin of the carapace. Scutum unarmed but furnished with a transverse row of small denticles above the anterior margin on each side. First and fifth tergal grooves distinct, other grooves absent. A median pair of granules on tergal Areas I and II. A transverse row of granules on each of the other Areas and free tergites. Sternum long and narrow. Respiratory spiracles large and not concealed. Legs unarmed. The calcaneus of each leg straight and much shorter than the astragalus. That of leg I in the male not notched below. The number of segments in tarsus I varies from 4-5 in the male but is constant at 4 in the female. In tarsus II the number of segments varies from 11-16 in the male and from 7-13 in the female. Tarsi III and IV have 4 segments each in both sexes. Distitarsus I has 2 segments in both sexes. Distitarsus II has 5-6 in the male and 4-5 in the female. The claws of tarsi III and IV are three-pronged, the middle prong being smaller than the lateral prongs.

Genotype: *Tasmanonyx montanus* sp. n.

Type Locality: Mount Wellington, Tasmania.

Forster (1954, p. 247) has established the subfamily Soerensenellinae for those Triaenonychidae in which the lateral prongs of the claws of tarsi III and IV are equal in length to, or longer than, the median prong. He has assigned to the subfamily the two South African genera *Roeweria* Lawrence and *Speleomontia* Lawrence and the two New Zealand genera *Soerensenella* Pocock and *Karamea* Forster. The Tasmanian genus *Tasmanonyx* differs from *Roeweria* in having large unconcealed respiratory spiracles, from *Speleomontia* in the form of the eyemound, from *Soerensenella* in the position of the eyemound and from *Karamea* in tarsal segmentation.

TASMANONYX MONTANUS sp. n.

(Figures 1-7)

Holotype Male

Measurements in millimeters: Body-length 4·85, length of scutum 3·88, length of carapace 1·71.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·91	0·46	2·00	0·86	1·54	2·06	1·43	9·26
Leg 2	1·71	0·57	2·86	1·09	2·28	2·97	2·86	14·34
Leg 3	1·49	0·51	1·88	0·86	1·43	2·28	1·60	10·05
Leg 4	1·77	0·74	2·57	1·03	2·00	3·43	2·00	13·54
Pedi-palp	0·57	0·51	1·88	1·03	1·43	....	1·26	6·68

Colour (in alcohol): Scutum brown with a dark region on each side. A median light brown stripe between two narrow dark brown patches extends from the eyemound to the scutal furrow. Behind the scutal furrow is a median wedge-shaped area reaching to the posterior margin of the scutum. It is composed of four short transverse dark brown bars, one on each of the tergal Areas I-IV. Area V and the free tergites are dark brown. Chelicerae, pedipalpi and legs are light brown with dark markings. The calcaneus of each leg is yellowish. Coxae, sternum and genital operculum light brown with darker brown markings. Abdominal sternites dark brown with a light brown bar between the spiracles.

Scutum (fig. 1) smooth and unarmed except for a transverse row of four small denticles above the anterior margin on each side. Scutal groove distinct medianly. The fifth tergal groove shallow, other grooves absent. A median pair of rounded granules is present on each of tergal Areas I and II, a recurved row of four granules on each of Areas III and IV and a transverse row of about 15 granules on Area V and each free tergite. The eyemound broadly conical and rising directly from the front margin. It is produced into a short point above in front. A few granules are present on each side of the base of the eyemound.

Chelicerae (fig. 2) are moderately strong. The first segment measures 1·14 mm. long and is armed with a median dorsal apical tooth and a row of three smaller teeth on the retrodorsal margin in the proximal half. The second segment is 1·43 mm. long and is unarmed.

Pedipalpi (fig. 3) well developed. The trochanter is armed above with a large tooth. The dorsal surface of the femur has a median row of six teeth. The retrolateral surface is smooth. The prolateral surface has a large tooth in the distal half and a few very small teeth near the prodorsal margin. The ventral surface is armed with a large median proximal tooth, which is somewhat bifid, being furnished with a posterior cusp. The retroventral margin is armed with a row of three teeth, the first of which is the largest. One or two small granules are also present in the row. The proventral margin is furnished with a row of very small granules. The patella has a large curved prolateral tooth. The tibia is armed with three teeth on each side and is slightly tuberculate on the ventral surface. The tarsus has three teeth on each side.

Coxa I has a promarginal row of three very small teeth, the apical tooth being blunt and coarsely bifid. Coxa II is armed with two teeth behind the apex. Coxa III is furnished with a few marginal granules in front of and behind the distal third. Coxa IV has a small tooth in front of the apex and a few granules near the distal end of the posterior margin.

The genital operculum and sternum have the form shown in fig. 4. The penis (fig. 5) has a ventral plate, which is cleft into two parts, each of which has a stout seta on the inner side and is clothed with minute spinules towards the apex. On each side below the ventral plate is a short leaf-like lateral plate. The distal end of the penis is short and tubular. It is protected on each side by a large lateral process.

The respiratory spiracles are large and conspicuous.

The legs are unarmed except for a few granulations on the femora. Each calcaneus is much shorter than the astragalus. The calcaneus (fig. 6) of leg I forms about ¼ the length of the metatarsus. It is straight and not notched below. The number of segments in tarsi I-IV is 5, 14, 4, 4. Distitarsi I and II have 2 and 6 segments respectively. The claws of tarsi III and IV are three-pronged, the middle prong being smaller than the lateral prongs (fig. 7).

Allotype Female

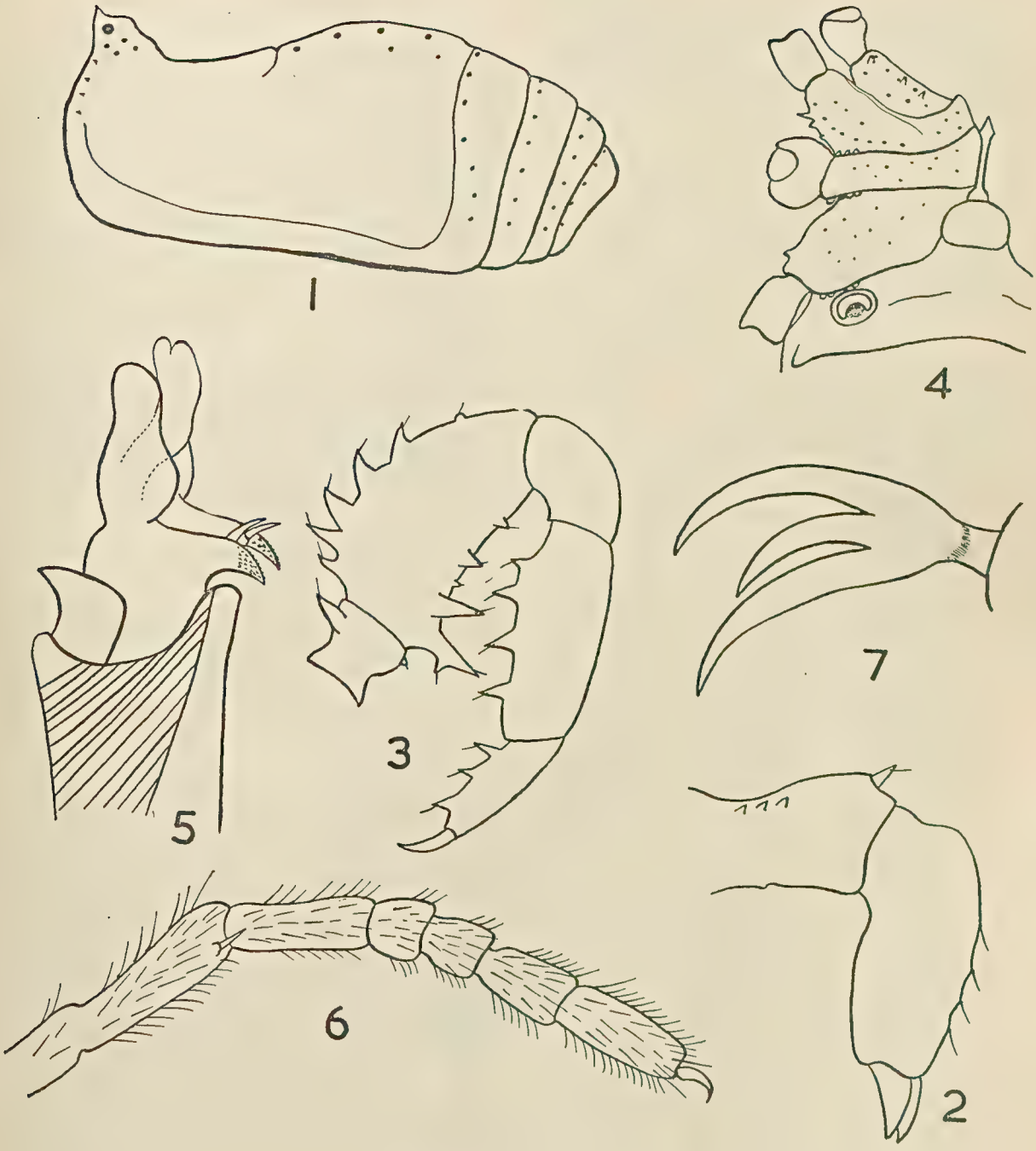
Measurements in millimeters: Body-length 4·17, length of scutum 3·54, length of carapace 1·71.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·97	0·46	1·60	0·80	1·26	1·54	1·26	7·89
Leg 2	1·60	0·51	2·17	0·91	1·83	2·40	2·34	11·76
Leg 3	1·31	0·51	1·60	0·69	1·20	1·83	1·26	8·40
Leg 4	1·60	0·74	2·06	0·86	1·71	2·86	1·60	11·43
Pedi-palp	0·57	0·46	1·43	0·80	0·97	....	0·97	5·20

The female resembles the male in colouration and general appearance. However, the dark bars on the tergal region of the scute are not confined to a median wedge-shaped area but extend laterally. The pedipalpi are shorter than those of the male and the proximal ventral tooth on the femur is more slender. The tarsal segmentation is 4, 10, 4, 4. Distitarsi I and II have 2 and 4 segments respectively.

Localities: The type specimens were collected near Saint Crispin's Well on the slope of Mount Wellington, 11th January, 1945. The species is very common at O'Grady's Falls and many other places on the mountain. It also occurs at Hastings, in the Arve Forest, and at National Park. The species is usually found in fern gullies, where it frequents moss, leaf-mould and decaying logs.

Variations: The collection contains 44 males and 35 females. The males vary in body-length from 3·48-5·22 and females from 3·89-5·10 mm. The number of segments in tarsus I varies in males from 4-5, but all the female specimens have four segments. The number of segments in tarsus II varies in males from 11-16 and in females from 7-14. Tarsi III and IV each have four segments in



Tasmanonyx montanus gen. et sp. n.

FIG. 1.—Lateral view of scutum and free tergites of male.
FIG. 2.—Retrolateral view of chelicera of male.
FIG. 3.—Retrolateral view of pedipalpus of male.
FIG. 4.—Ventral view of right coxae, sternum, genital operculum and spiracle of male.
FIG. 5.—Lateral view of penis.
FIG. 6.—Calcaneus and tarsus of leg I of male.
FIG. 7.—Claw of leg IV.

all specimens. Distitarsus I has two segments in all specimens but the number of segments in distitarsus II varies from 5-6 in males and 4-5 in females. Specimens in which tarsus II has the same number of segments in left and right appendages are comparatively rare and, as Table 1 shows, much asymmetry occurs.

Table 1.

Number of specimens.	Sex.	Number of segments in tarsus I.	Number of segments in tarsus II.	Number of segments in distitarsus II.
1	♂	4	11	5
1	♂	4	12	6
1	♂	4	12	6L 5R
3	♂	4	13	6
1	♂	4	13L 11R	5
1	♂	4	13L 12R	6L 5R
1	♂	4L 5R	10L 12R	5L 6R
1	♂	4L 5R	13	6
1	♂	4L 5R	13L 12R	5
1	♂	4L 5R	14L 13R	6
1	♂	5	11L 12R	5
1	♂	5	11L 13R	5L 6R
1	♂	5	12	6
1	♂	5	12	5L 6R
2	♂	5	12L 13R	6
1	♂	5	13L 11R	6L 5R
3	♂	5	13L 12R	6
1	♂	5	13	6
1	♂	5L 4R	13L 14R	6
1	♂	5L 4R	14L 13R	6
3	♂	5	13L 14R	6
1	♂	5	13L 15R	6
1	♂	5	14L 12R	6
1	♂	5	14L 12R	6L 5R
2	♂	5	14L 13R	6
3	♂	5	14	6
3	♂	5	14L 15R	6
1	♂	5	15L 14R	6
2	♂	5	15	6
1	♂	5	15L 16R	6
1	♂	5	16L 14R	6
1	♀	4	7L 9R	4
1	♀	4	8L 9R	4
2	♀	4	9	4
2	♀	4	9L 10R	4
1	♀	4	9L 10R	5
1	♀	4	9L 11R	4
1	♀	4	10L 8R	4
7	♀	4	10L 9R	4
10	♀	4	10	4
3	♀	4	10L 11R	4
4	♀	4	11L 10R	4
1	♀	4	12L 11R	4
1	♀	4	14L 13R	4

Genus **BRYONUNCIA** gen. n.

Carapace with a transverse row of small denticles above the anterior margin on each side. Eyemound low, rounded, unarmed and rising directly from the anterior margin. Scutum unarmed. First and fifth tergal grooves distinct, others indistinct. Each tergal Area and free tergite with a transverse row of rounded granules. Legs unarmed. Calcaneus of legs I and II much longer than astragalus. In males the calcaneus of leg I is notched below. Tarsal segmentation: 3, 5-6, 4, 4. The distitarsi I and II with two and three segments respectively. Claws of tarsi III and IV three-pronged, the middle prong larger than the lateral prongs.

Genotype: *Bryonuncia distincta* sp. n.

Type Locality: The Arve Forest, Geeveston, Tasmania.

In having the calcaneus of legs I and II much longer than the astragalus, the genus *Bryonuncia* resembles the South American genera *Triaenonyx* Soerensen and *Diasia* Soerensen and also the South African genera *Cryptobunus* Lawrence and *Biacumontia* Lawrence. However, it differs from all these genera in the form of the eyemound.

BRYONUNCIA DISTINCTA sp. n.

(Figures 8-15)

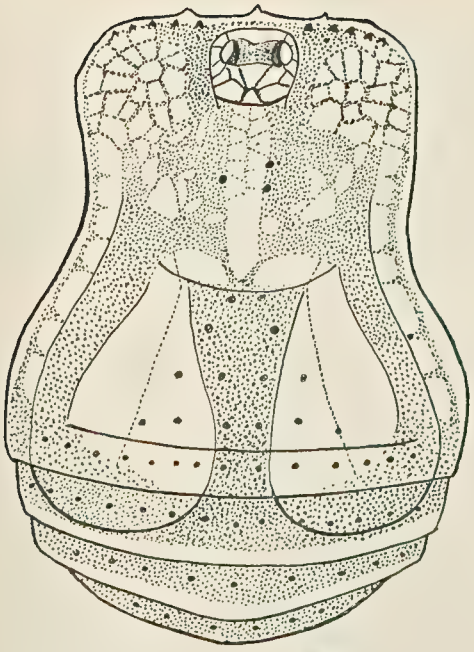
Holotype Male

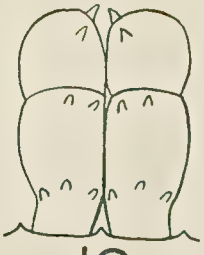
Measurements in millimeters: Body-length 3·14, length of scutum 2·80, length of carapace 1·31.

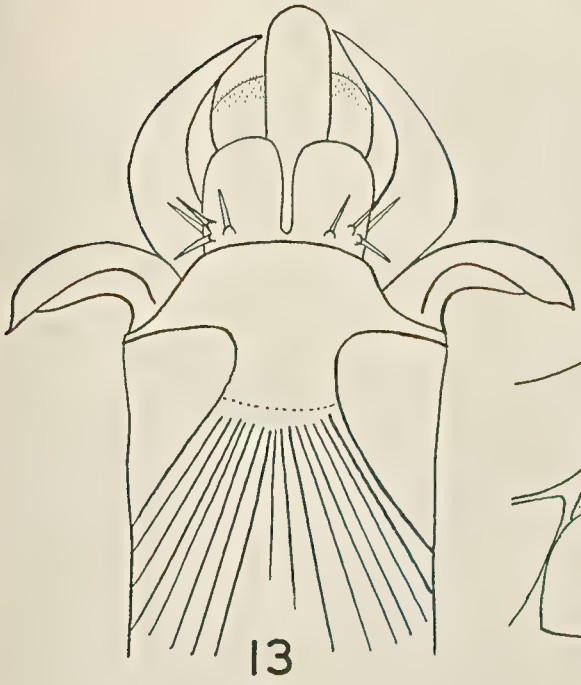
	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·46	0·34	1·08	0·57	0·63	0·91	0·80	4·79
Leg 2	0·86	0·34	1·42	0·63	0·86	1·43	1·43	6·97
Leg 3	0·91	0·30	0·80	0·46	0·63	0·74	0·80	4·64
Leg 4	0·97	0·40	1·26	0·68	1·03	1·37	0·97	6·68
Pedipalp	0·46	0·45	1·20	0·74	0·86	....	0·86	4·57

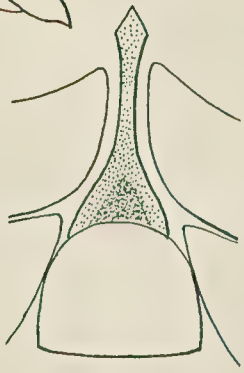
Colour (in alcohol): Scutum light-brown with dark-brown markings as indicated in fig. 8. The markings form a reticulate pattern on each side of anterior quarter. Carapace has a pair of dark-brown patches extending from the eyemound to the scutal groove. Behind the carapace is a median wedge-shaped dark brown region situated between two light-brown lobes, which form saddle-like area covering a large part of the abdominal scutum and extending onto the first free tergite. On each side the saddle-like area merges with a longitudinal dark-brown region, which extends forward to the reticulate pattern in the anterior quarter. Pedipalpi and chelicerae are light-brown with dark reticulations. Legs light-brown banded with dark-brown. Coxae light-brown with dark reticulations. Free sternites yellowish-brown with a dark-brown area on each side.

The surface of the dorsal scutum is finely shagreened and unarmed. Frontal margin has a row of five minute tubercles or granules above on each side. The eyemound (fig. 9) slopes down to the front. It is low, rounded and scarcely higher than the rest of the carapace. Behind the eyemound is a crescent-shaped row of small granules and at each side of it a shallow depression. A









Bryonuncia distincta gen. et sp. n.

FIG. 8.—Dorsal view of scutum and free tergites of male.
FIG. 9.—Lateral view of eyemound.
FIG. 10.—Dorsal view of chelicerae of male.
FIG. 11.—Retrolateral view of pedipalpus of male.
FIG. 12.—Sternum and genital operculum of male.
FIG. 13.—Ventral view of distal part of penis.
FIG. 14.—Leg I of male.
FIG. 15.—Metatarsus and tarsus of leg II of male.

few granules are situated near the middle of the carapace. The first and fifth transverse grooves are well marked, the others indistinct. Each scutal Area and free tergite is provided with a transverse row of small rounded granules.

Chelicerae large and stout. Dorsal surface of first segment provided with a median and an inner tubercle at the apex and a transverse row of three tubercles behind the middle (fig. 10). The second segment furnished in front with several conical tubercles, three of which form an inner longitudinal row.

The pedipalpi large and strong. The trochanter has three tubercles in a transverse row above and three below. The femur has a median dorsal row of three teeth and four small tubercles, the teeth alternating with the tubercles. On the ventral surface there is a median basal tooth, and a row of small rounded tubercles on each margin. The prolateral surface has two upper and one lower tooth in the distal third. The retrolateral surface has a lower row of about four rounded granules. The patella is smooth and unarmed. The tibia has three teeth on each side, the third prolateral tooth being the largest. A few tubercles are present on the ventral surface. The tarsus has three teeth on each side. The claw is about ⅓ the length of the segment (fig. 11).

Coxa I has a row of two small tubercles on the front margin, the apical tubercle being bifid. Coxa II is coarsely tuberculate behind the distal end and has a few granules in front. It is provided with two tubercles above. Coxa III has a marginal row of granules in front and behind. Coxa IV is tuberculate in front of the distal end and has a few marginal granules behind the distal third.

The sternum and genital operculum have the form shown in fig. 12. The operculum is finely shagreened but smooth and rounded in front. The penis (fig. 13) has a deeply cleft ventral plate furnished with one pair of superior and three pairs of inferior setae. The glans has the form of a short wide tube with a bluntly rounded end. Above the glans is a wide dorsal plate, which is curved and finely spiculate in front. On each side the glans is protected by a wide pointed process, which curves inwards. At each side of the base of the ventral plate a wing-like lateral process curves outwards from the distal end of the trunk of the penis.

The free sternites are finely shagreened. The respiratory spiracles are oval in shape and not concealed.

The legs are short and stout. They are unarmed but the femora are somewhat tuberculate. In legs I and II the calcaneus is much longer than the astragalus, that of the first leg (fig. 14) being about 7/10 the length of the metatarsus and that of the second leg about 6/7 the length of the metatarsus (fig. 15). In legs III and IV the calcaneus is shorter than the astragalus, being about 2/5 the length of the metatarsus in the case of leg III and 1/5 in the case of leg IV. Calcaneus I has a ventral notch at its distal end. Metatarsi III and IV each have a false joint near the base. The tarsal segmentation is 3, 6, 4, 4. Distitarsi I and II have two and three segments respectively. Claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

Allotype Female

Measurements in millimeters: Body-length 3·03, length of carapace 1·14, length of scutum 2·17.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·46	0·29	0·91	0·46	0·63	0·80	0·74	4·29
Leg 2	0·85	0·34	1·26	0·57	0·80	1·31	1·26	6·39
Leg 3	0·80	0·29	0·80	0·46	0·57	0·68	0·69	4·29
Leg 4	0·86	0·40	1·14	0·63	0·91	1·26	0·97	6·17
Pedipalp	0·46	0·40	1·03	0·63	0·68	....	0·68	3·88

The female closely resembles the male in colouration and general features. However, the saddle-like area on the dorsal scutum is much smaller. The pedipalpi are shorter and less robust. The calcaneus of leg I is straight and not notched. The tarsal segmentation is 3, 5, 4, 4. Distitarsi I and II have two and three segments respectively.

Localities: The holotype and allotype were collected in the Arve Forest at Geeveston, Tasmania, 22nd November, 1955. The species also occurs on Mt. Wellington. The harvestman is usually found in moss.

Variations: The collection contains 17 males and 22 females. The body-length of the males is 2·51-3·25 mm. and of the females 2·46-3·03 mm. The variations in the segmentation of tarsi I and II are shown in Table 2.

Table 2

Number of specimens	Sex	Number of segments in tarsus I	Number of segments in tarsus II	Number of segments in distitarsus I	Number of segments in distitarsus II
1	♂♀	3	5	2	3
1	♂♀	3	5L, 6R	2	3
15	♂♀	3	6	2	3
8	♀	3	5	2	3
11	♀	3	6	2	3
1	♀	3	5L, 6R	2	3
1	♀	3	6L, 5R	2	3
1	♀	2L, 3R	6	1L, 2R	3

Genus **PYENGANELLA** gen. n.

Scutum unarmed. Eyemound rounded, unarmed and situated in the anterior third of the carapace. Scutal and tergal grooves distinct. Tergal Areas I-IV each with a transverse row of small blunt tubercles, the median pair in each row larger than the others. Area V and each free tergite with a transverse row of rounded granules. Legs unarmed but femora, patellae and tibiae coarsely granular. Calcaneus of leg I slightly longer than astragalus; straight and not notched below in the male. Calcaneus of leg II slightly shorter than the astragalus. Calcaneus of leg III and that of leg IV much shorter than the astragalus. Tarsal segmentation: 4, 11-16, 4, 4. Distitarsus I has two segments, distitarsus II 4-6 segments. Claws of tarsi III and IV three-pronged, the middle prong being larger than the lateral prongs.

Genotype: *Pyenganella striata* sp. n.

Type locality: Near St. Columba Falls, Pyengana, Tasmania.

In having four segments in tarsus I *Pyenganella* resembles the South American genus *Triaenonyx* Soerensen and differs from the other genera in which the calcaneus of leg I is longer than the astragalus. It differs from *Triaenonyx* in having more than three segments in distitarsus II and in the calcaneus of legs II, III and IV being shorter than the astragalus.

PYENGANELLA STRIATA sp. n.

(Figures 16-21)

Holotype Male

Measurements in millimeters: Body-length 2·63, length of scutum 2·45, length of carapace 1·26.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·57	0·29	1·31	0·63	0·97	1·20	0·97	5·94
Leg 2	1·09	0·37	1·83	0·80	1·49	1·65	1·90	9·13
Leg 3	0·91	0·40	1·26	0·62	1·03	1·20	1·14	6·56
Leg 4	1·09	0·46	1·71	0·76	1·37	1·71	1·37	8·47
Pedipalp	0·46	0·40	1·31	0·79	0·86	....	0·80	4·62

Colour (in alcohol): Carapace yellowish-brown with dark-brown markings at the sides of and behind the eyemound. Tergal Areas dark-brown with a row of large yellowish-brown spots above the margin on each side. Free tergites dark-brown. Chelicerae, pedipalpi and coxae yellowish-brown with dark reticulations. Legs and free sternites dark-brown.

Scutum (fig. 16) unarmed. Surface granular and marked with numerous longitudinal ridges extending posteriorly as far as the groove between tergal Areas IV and V. Eyemound rounded and unarmed; situated about $\frac{1}{3}$ of its basal diameter from the front margin. All tergal grooves except the second are well marked. The second is faintly marked. A median pair of small tubercles on Area I, a transverse row of four small tubercles on Areas II and III, and a row of about eight on Area IV. The median pair on Area IV being larger and wider apart than the others. Area V and each free tergite with a transverse row of rounded granules.

Basal segment of chelicerae measures 0·80 mm. long and is smooth. The second segment measures 1·20 mm. long and has on the frontal surface a small denticle near the base and one near the middle on the inner side.

Pedipalpi (fig. 17) large and strong. The trochanter has a small blunt tubercle above and below. The femur, which is large and somewhat swollen, has no spines or tubercles on the dorsal surface or on the prolateral and retrolateral surfaces. On the ventral surface there is a small basal tooth and a row of three granules on the retroventral margin. The patella is smooth. Tibia has three short stout teeth on the retrolateral side and two smaller teeth on the prolateral side. Tarsus has three small teeth on each side.

Coxa I with three small blunt tubercles or granules on the anterior margin. Coxa II coarsely granular behind apex. A marginal row of granules in front of and behind coxa III and also behind coxa IV. All coxae have rounded granules on the ventral surface, but are without spines or spinous tubercles.

The genital operculum and sternum have the form shown in fig. 18. The operculum is large and longer than wide. Its surface is finely granular and clothed with a few scattered hairs. The form of the penis in the retracted condition is shown in fig. 19. The ventral plate is divided into two long narrow concave dark lobes, below which are three pairs of inferior setae. Projecting on each side of the ventral plate is a long superior seta. The paired lateral processes are not fully extended. Their distal ends are narrow and leaf-like. The glans terminates in a laterally compressed tube.

Each free sternite is provided with two transverse rows of granules. The respiratory spiracles are partly concealed under granules on the posterior margin of coxa IV.

The legs are unarmed but all the femora, patellae and tibiae are coarsely granular. In leg I the calcaneus is slightly longer than the astragalus, Calcanei I-IV form 4/7, 3/7, 2/7 and 1/5 of the respective metatarsi (figs. 20 and 21). The tarsal segmentation is 4, 14, 4, 4. Distitarsi I and II have two and five segments respectively. Claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

Allotype Female

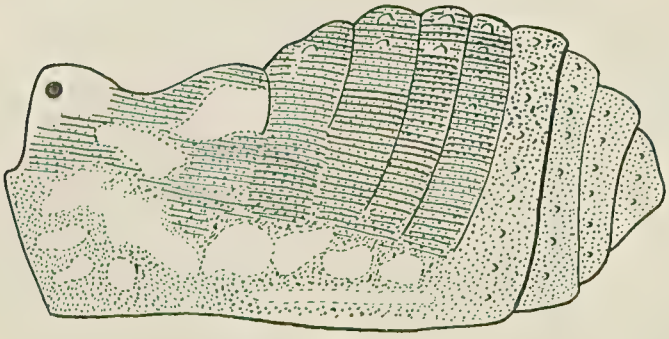
Measurements in millimeters: Body-length 2·97, length of scutum 2·50.

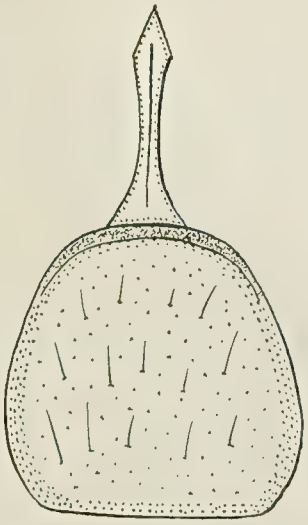
	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·57	0·29	1·20	0·57	0·91	1·14	0·97	5·65
Leg 2	0·86	0·34	1·59	0·69	1·31	1·43	1·77	7·99
Leg 3	0·79	0·34	1·14	0·57	0·97	1·14	1·08	6·03
Leg 4	1·03	0·46	1·60	0·69	1·31	1·60	1·26	7·95
Pedipalp	0·45	0·40	0·91	0·57	0·74	....	0·68	3·75

The female resembles the male in colouration, size and general features. The pedipalpi, however, are smaller than those of the male and the femur has two small tubercles on the prolateral surface. The patella also has a prolateral tubercle. The three retrolateral teeth on the tibia are not as stout as in the male. The number of segments in tarsi I-IV is 4, 12, 4, 4. The distitarsi I and II have two and four segments respectively.

Localities: The type specimens were collected under decaying logs near St. Columba Falls, Pyengana, Tasmania, 17th April, 1954. The species also occurs in *Notofagus* forest at the foot of Mount Barrow.

Variations: The collection contains 13 males and 6 females. The males vary in body-length from 2·34-2·85 and the females from 2·32-3·48 mm. In some specimens the eyemound is furnished above in front with a small granule or denticle. In all specimens of both sexes tarsi I, III and IV each have four segments. The number of segments in tarsus II and its distal section (distitarsus II) varies as shown in Table 3.





Pyenganella striata gen. et sp. n.

Fig. 16.—Lateral view of scutum and free tergites of male.
Fig. 17.—Retrolateral view of pedipalpus of male.
Fig. 18.—Sternum and genital operculum of male.
Fig. 19.—Ventrolateral view of penis.
Fig. 20.—Metatarsus and tarsus of leg I of male.
Fig. 21.—Metatarsus and tarsus of leg II of male.

Table 3

Number of specimens	Sex	Number of segments in tarsus II		Number of segments in distitarsus II	
1	♂	11L	12R	5	
1	♂	12L	13R	5L	4R
2	♂	13		5	
1	♂	13L	12R	5	
1	♂	13L	12R	6L	5R
1	♂	13L	16R	5L	6R
1	♂	14L	13R	5	
2	♂	14		5	
1	♂	14L	15R	6	
1	♂	15L	13R	5	
1	♂	16L	14R	6L	5R
1	♀	11L	12R	4	
3	♀	12		4	
1	♀	12		4L	5R
1	♀	13L	12R	4	

Genus **LOMANELLA** Pocock, 1903

Anterior margin of carapace unarmed. Eyemound removed from front margin and unarmed. Scutum and free tergites without spines. Pedipalpus weakly armed. Legs unarmed. Calcaneus of each metatarsus shorter than astragalus. Tarsal segmentation: 2-3, 2-5, 3-4, 3-4. Third and fourth tarsal claws are three-pronged, the middle prong being larger than the lateral prongs. Sternum long and narrow. Respiratory spiracles not concealed.

Genotype: *Lomanella raniceps* Pocock.

Type locality: Tasmania.

The genus Lomanella contains one Victorian species, *Lomanella kallista* Forster, and three Tasmanian species, *L. raniceps* Pocock, *L. atrolutea* Roewer and *L. parva* Forster. A new species from Tasmania is described in the present paper. The five species may be distinguished by the following key.

The figure of *Lomanella raniceps* given by Roewer (1923, p. 595, fig. 743) shows a lateral view of the body and is stated to be "nach Pocock". However, on comparing the figure with that given by Pocock (1903, p. 410, Text-fig. 84 B), two marked differences are apparent. Firstly, Roewer's figure shows the femur of the pedipalpus to be much reduced in the basal half and secondly, the figure depicts the summit of the eyemound higher than the highest part of the scutum. In Pocock's figure no great reduction in the basal half of the femur is indicated and the eyemound is shown distinctly lower than the highest part of the scutum. All specimens examined by me conform to the figure given by Pocock.

The harvestman is one of the most common species in Tasmania and in the course of the present investigation over a hundred specimens from many different parts of the State have been examined. Several new features, especially the male genitalia, have been studied and are described in the following account of the species.

Male

Measurements in millimeters: Body-length 2·91, length of scutum 2·40, length of carapace 1·09.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·63	0·29	1·03	0·46	0·80	1·03	0·63	4·87
Leg 2	0·91	0·34	1·48	0·63	1·34	1·54	1·03	7·27
Leg 3	0·74	0·37	1·14	0·54	0·91	1·09	0·63	5·42
Leg 4	0·91	0·45	1·43	0·57	1·26	1·60	0·69	6·91
Pedipalp	0·57	0·34	0·97	0·63	0·68	....	0·63	3·82

Colour (in alcohol): Carapace yellow with dark-brown reticulations immediately behind the anterior margin and between the eyemound and the scutal furrow. At the sides the carapace is dark-brown with a yellow margin. Tergal region of scute dark-brown with transverse yellow bars or spots. Three yellow marginal spots on each side. Free tergites yellow marked with dark-brown in the middle and on each side. Chelicerae and pedipalpi yellow and shining, the pedipalpi with dark-brown tarsi and dark-brown reticulations on the basal half of femur, patella and tibia. Legs dark-brown with a yellowish band in the apical half of femora and tibiae. Coxae and genital operculum yellow, the coxae darker at apex. Sternites mainly yellow marked with dark-brown on each side and with a double row of dark-brown spots in the middle.

Scutum (figs. 22 and 23) with a slight marginal projection above the base of leg II. Surface finely granular, devoid of spines and tubercles. Eyemound rounded and smooth, removed 0·29 mm. from the anterior margin. The scutal groove short but distinct. Tergal region higher than summit of eyemound. Tergal grooves faintly marked, that between Areas IV and V more dis-

KEY TO SPECIES IN THE GENUS *LOMANELLA*

1. Eyemound conical .... *L. kallista* Forster.
   Eyemound rounded 2
2. Tarsus of leg II with five segments 3
   Tarsus of leg II with less than five segments 4
3. Femur I with three ventral tubercles .... *L. raniceps* Pocock.
   Femur I without tubercles .... *L. atrolutea* Roewer.
4. Four rows of granules on tergal region .... *L. parva* Forster.
   No rows of granules on tergal region .... *L. exigua* n. sp.

LOMANELLA RANICEPS Pocock

(Figures 22-29)

The type of specimen of this species came from Tasmania and was described and figured by Pocock (1903, p. 411). A more detailed description based on a male and a female specimen was published by Roewer (1914, p. 84). Pocock did not state the sex of the type specimen, but Roewer (1914, p. 86) assumed it to be a female. However, as he had not seen the specimen, he was doubtful as to its sex and later (1923, p. 596) considered it to be a male.

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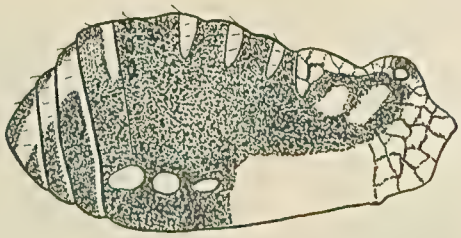

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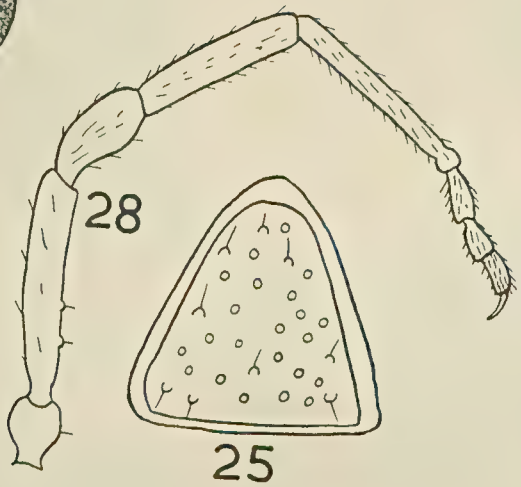

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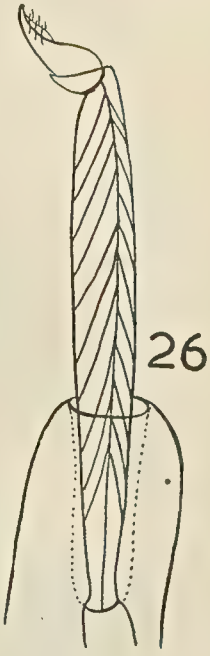

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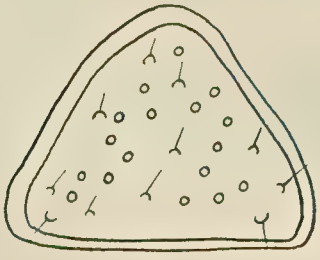

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27

Lomanella raniceps Pocock.

FIG. 22.—Dorsal view of scutum and free tergites of male.
FIG. 23.—Lateral view of scutum and free tergites of male.
FIG. 24.—Retrolateral view of pedipalpus of male.
FIG. 25.—Genital operculum of male.
FIG. 26.—Lateral view of penis.
FIG. 27.—Ventral view of distal part of penis.
FIG. 28.—Leg I of male.
FIG. 29.—Genital operculum of female.

tinct than the others. A transverse row of minute hairs on each tergal area and free tergite.

Chelicerae small and unarmed. Basal segment 0·76 mm. long, with a deep transverse depression near middle of dorsal side and the apical half high and rounded. The second segment 0·68 mm. long.

Pedipalpi without coarse teeth. Femur and tibia somewhat swollen (fig. 24). Femur with a small tubercle near the base on the ventral side and a somewhat smaller one near the middle of the prolateral surface. Tibia with a long curved seta rising from a tubercle below on each side. Tarsi with three curved setae on each side. Claw almost straight.

Coxae and sternites finely granular. A posterior marginal row of larger granules on coxae III and IV. Two small posterior tubercles and a wide dorsal tubercle on coxae II. Genital operculum (fig. 25) triangular, 0·41 mm. wide at the base and 0·41 mm. long from base to apex, surface finely granular and with a few scattered setae.

The penis (fig. 26) is 1·29 mm. long when extended. It is strongly narrowed at the base and becomes wider distally. The glans penis is pointed anteriorly and somewhat spoon-shaped. It is furnished with three small setae on each side (fig. 27). A pair of wide dorsal plates cover the base of the glans at its junction with the trunk of the penis.

Legs finely granular and unarmed. Three small tubercles are present below femur I (fig. 28). Calcaneus small and knob-like. Tarsal formula: 3, 5, 4, 4. Distitarsus I has two segments and distitarsus II has three.

Respiratory spiracles not concealed by the fourth coxae.

Female

Measurements in millimeters: Body-length 2·97, length of scutum 2·57, length of carapace 1·03.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·63	0·27	1·01	0·44	0·77	0·96	0·60	4·68
Leg 2	0·91	0·31	1·41	0·59	1·22	1·40	0·97	6·81
Leg 3	0·80	0·37	1·10	0·52	0·90	1·18	0·69	5·56
Leg 4	0·97	0·36	1·42	0·62	1·22	1·56	0·82	6·97
Pedipalp	0·41	0·27	0·82	0·55	0·64	....	0·55	3·24

The female resembles the male in size and general appearance. It may be distinguished from the male by having less robust pedipalpi and a distinctly wider genital operculum, which measures 0·51 mm. wide at the base and 0·37 mm. long from base to apex (fig. 29).

Locality: *Lomanella raniceps* is one of the most wide-spread opilionids in Tasmania. Specimens have been collected at Mt. Wellington, the Arve Forest at Geeveston, Hastings, Nugent, Eaglehawk Neck, Highcroft, Mt. Hobbs, National Park, Tarraleah, Great Lake, Lake St. Clair, Liffey Falls, Trevallyn, Forth Falls, Western Creek, Scottsdale, Weldborough and many other places in the State. Adult specimens may be found throughout the year. They often occur under charred fallen logs in moderately damp localities.

Variations: The normal tarsal segmentation, 3, 5, 4, 4 in both sexes is very constant. As shown in Table 4 only three specimens out of a hundred showed any departure from the normal number of segments.

Table 4.

Number of specimens	Sex	Number of segments in tarsus I	Number of segments in tarsus II	Number of segments in distitarsus I	Number of segments in distitarsus II
55	♂♂	3	5	2	3
1	♂♂	3	4L 5R	2	2L 3R
42	♀♀	3	5	2	3
1	♀♀	3	5L 4R	2	3
1	♀	3	5L 2R	2	3L 1R

LOMANELLA ATROLUTEA Roewer

(Figures 30-33)

The description of this species given by Roewer (1914, p. 86) is based on two male specimens from Tasmania. The harvestman is by no means common and the collection before me contains only two examples, one a male, the other a female.

Male

Measurements in millimeters: Body-length 4·28, length of scutum 3·83, length of carapace 1·77.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·97	0·46	1·88	0·74	1·43	1·71	0·86	8·05
Leg 2	1·14	0·57	2·63	0·97	2·40	2·74	1·49	11·94
Leg 3	1·13	0·51	1·94	0·86	1·60	2·17	1·03	9·42
Leg 4	1·60	0·63	2·74	1·03	2·17	2·97	1·14	11·68
Pedipalp	0·69	0·46	1·77	1·09	1·43	....	1·14	6·58

Colour (in alcohol): Carapace yellow with dark-brown reticulations in front of and at the sides of the eyemound. A large yellow V-shaped area extends from behind the eyemound to slightly beyond the middle of the tergal region. The yellow region encloses three dark-brown spots in the mid line, one on each of the tergal Areas I, II and III. Posteriorly and on each side the scutum is brown, but has three yellow spots on each side of the posterior half. The free tergites are yellow with a brown area on each side and in the middle. The brown lateral regions of the first two free tergites each enclose a yellow spot. Chelicerae yellow with dark reticulations. Pedipalpi with dark-brown patella, tibia and tarsus; the femur is yellow except for the proximal half of the retrolateral side and a small dorsal apical region which are brown. Legs dark-brown except for the trochanters and distal half of femora, which are yellow with brownish markings. Coxae yellow with brown infuscation towards the apex. Genital operculum light-brown. Sternites yellow with brown in the middle and at the sides.

Scutum finely granular but without spines and tubercles. The lateral margin forms a slight angular projection above the base of leg II. Eyemound smooth, rounded, and removed about 0·4 mm. from the front margin. Summit of eyemound slightly lower than the highest part of the tergal region. Scutal groove distinct. Tergal grooves slightly indicated. Free tergites granular but without tubercles (figs. 30 and 31).

Chelicerae short and unarmed. Pedipalpi without spines. The femur and tibia somewhat swollen. A long seta below the base of the femur. No setae on patella. A prolateral and a retrolateral seta below the apical half of the tibia. Three setae on each side of the tarsus. Claw long and but slightly curved (fig. 32).

Coxae granular. The third pair with a marginal row of large granules in front and behind. Fourth pair with a marginal row behind. Respiratory spiracles conspicuous. Genital operculum triangular, 0·48 mm. wide at the base and 0·51 mm. long. Sternum narrow.

Legs long, slender and smooth (fig. 33). All segments devoid of spines and tubercles. Calcaneus small and knob-like. Tarsal formula: 3, 5, 4, 4.

Distitarsus I with two segments, distitarsus II with three segments. Third and fourth tarsal claws three-pronged, the middle prong longer and stronger than the lateral prongs.

Allotype Female

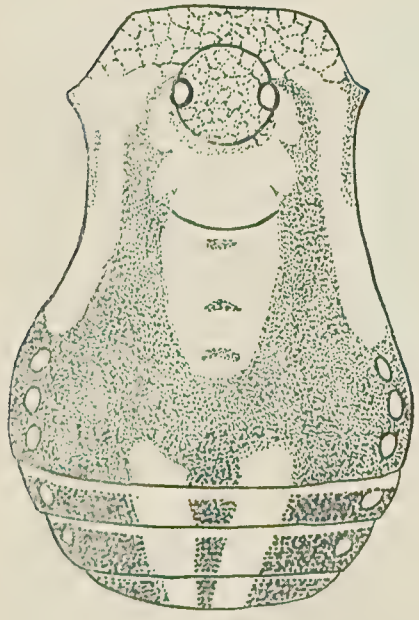
Measurements in millimeters: Body-length 4·00, length of scutum 3·20, length of carapace 1·14.

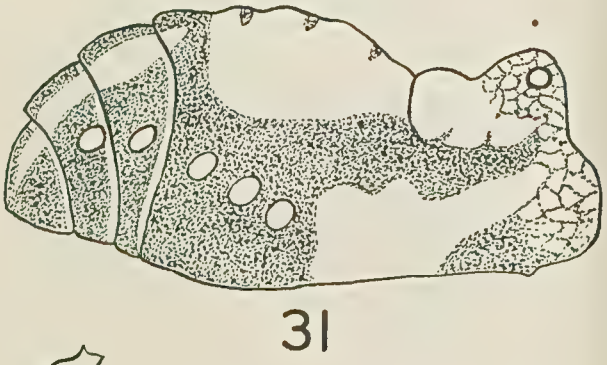
	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	1·09	0·46	1·83	0·69	1·37	1·71	0·91	8·06
Leg 2	1·37	0·57	2·46	0·91	2·28	2·51	1·43	11·53
Leg 3	1·14	0·46	1·88	0·86	1·49	2·17	0·97	8·97
Leg 4	1·37	0·57	2·40	0·86	1·88	2·97	1·14	11·19
Pedipalp	0·69	0·51	1·60	0·80	1·14	....	0·91	5·65

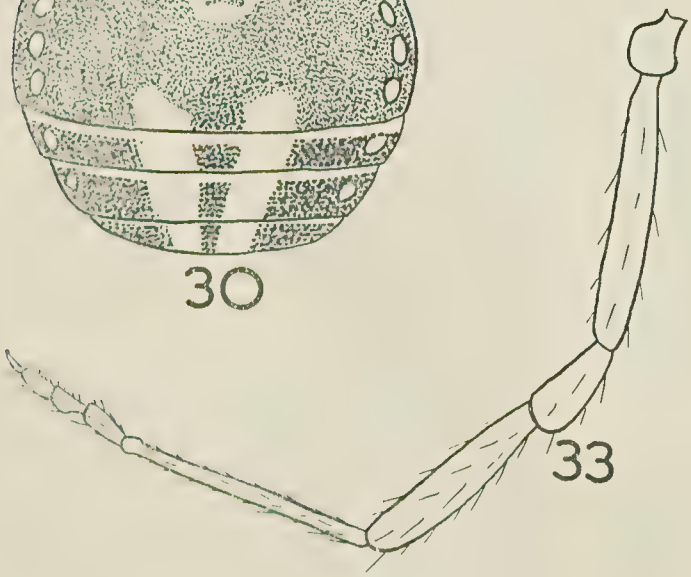
The female resembles the male in colour, markings and general structure. The pedipalpus is shorter and less swollen than that of the male but has the same arrangement of setae. The genital operculum measures 0·63 mm. wide at the base and 0·46 mm. long, and therefore differs from that of the male.

Locality: The male was found by D. E. Kurth near the Interview River on the West Coast of Tasmania, 2nd January, 1954. The allotype female was found at Daisy Dell, on the road from Wilmot to the Cradle Mountain, December, 1927.

Lomanella atrolutea resembles *Lomanella raniceps* in most features but differs in colour pattern, in having no tubercles below femur I and in being much larger.







Lomanella atrolutea Roewer.

Fig. 30.—Dorsal view of scutum and free tergites of male.
Fig. 31.—Lateral view of scutum and free tergites of male.
Fig. 32.—Retrolateral view of pedipalpus of male.
Fig. 33.—Leg I of male.

Colour and general structure as in the male. The pedipalpi, however, are not so swollen. The genital operculum is 0·34 mm. wide at the base and 0·22 mm. long.

Locality: The Arve Forest at Geeveston, Tasmania, 1st December, 1955. The holotype and allotype together with nine other males and eight other females were collected from moss in rain forest areas.

Variations: Of the nineteen specimens collected ten males and eight females all had the same tarsal segmentation, 3, 3, 4, 4. One adult female, however, had a tarsal segmentation of 2, 2, 4, 4.

Lomanella exigua closely resembles *Lomanella parva*, Forster, in size, in the tarsal segmentation of the female and in the form of the eyemound, pedipalpus and chelicera. It differs in lacking transverse rows of granules on the tergal region of the scutum, in the tarsal segmentation of the male and in the structure of the penis.

LOMANELLA PARVA Forster.

The description of this species given by Forster (1955, p. 390) is based on a male and female specimen found in leafmould at Wallaby Beach, Port Davey, Tasmania, 29th January, 1954. The tarsal segmentations of the male (2, 2, 3, 3) is so unusual that, as Forster remarks, it needs confirmation by the examination of further specimens. The species is not represented in the collection before me but it appears to be so closely related to *Lomanella exigua*, that one might expect it to have the same tarsal formula, 3, 3, 4, 4, in both sexes, instead of in the female only. As pointed out in the description of variations found in *Lomanella exigua*, one of the females collected had the anomalous tarsal formula 2, 2, 4, 4.

Genus **ANKYLONUNCIA** gen. n.

Scutum unarmed but furnished on each side with a row of small tubercles or granules above the anterior margin. Eyemound low, wider than high and unarmed. Tergal Areas and free tergites each with a row of small granules or tubercles. Basal segment of chelicerae without a retrodorsal proximal, boss or condyle in both sexes. Calcaneus of leg I in males notched below. Number of segments in tarsi I-IV in males is 3-4, 6-10, 4, 4. and in females 3, 6-9, 4, 4. Distitarsi I and II have two and three segments respectively. The claws of tarsi III and IV are three-pronged, the middle prong being longer than the lateral prongs.

Genotype: *Ankylonuncia fallax* sp. n.

Type Locality: Tunnack, Tasmania.

The genus *Ankylonuncia* is close to *Notonuncia* gen. n. but differs from the latter genus in not possessing a proximal retrodorsal boss on the basal segment of the chelicerae in males and also in having a smaller number of segments in tarsus II. There is some resemblance to the New Zealand genus *Nuncia*. However, in *Nuncia* the calcaneus of leg I in males is never notched. Three new species have been assigned to the genus *Ankylonuncia*. They may be distinguished by the following key.

LOMANELLA EXIGUA sp. n.

(Figures 34-40)

Holotype Male

Measurements in millimeters: Body-length 1·60, length of scutum 1·37, length of carapace 0·63.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·34	0·18	0·51	0·29	0·40	0·44	0·48	2·64
Leg 2	0·44	0·19	0·72	0·37	0·56	0·58	0·62	3·48
Leg 3	0·44	0·19	0·59	0·33	0·47	0·53	0·41	2·96
Leg 4	0·58	0·22	0·77	0·38	0·62	0·70	0·47	3·74
Pedipalp	0·30	0·18	0·53	0·36	0·36	....	0·45	2·18

Colour (in alcohol): Carapace yellow with brownish reticulations in front and behind the black eyemound. Sides brown with a yellow region below. Lateral margins brown. Tergal region of scutum brown with transverse yellow bars above and a wide yellow margin below at the sides. Free tergites yellow with a brown region on each side. Pedipalpi and chelicerae yellow with faint brown reticulations. Coxae and genital operculum yellow. Sternites yellow with brown markings on each side. Legs brown, with femora, patellae and tibiae paler distally.

Eyemound smooth and rounded, removed about 0·15 mm. from the front margin. Surface of scutum finely granular but without spines and tubercles. The margin of the scutum forms a slight angular projection anterolaterally and above the base of leg II. Scutal furrow distinct. Tergal region higher than eyemound, tergal grooves indistinct (figs. 34 and 35).

Chelicerae unarmed. Basal segment 0·42 mm. long, with a deep mid dorsal depression and strongly convex apical region (fig. 36). Second segment 0·52 mm. long. Pedipalpus slightly longer than body. Femur and tibia somewhat swollen. Three setae below the femur and a large seta on the prolateral side. Patella without setae. Tibia with a large retrolateral and a smaller prolateral seta below. Tarsus with three setae on each side. Claw slightly curved (fig. 37).

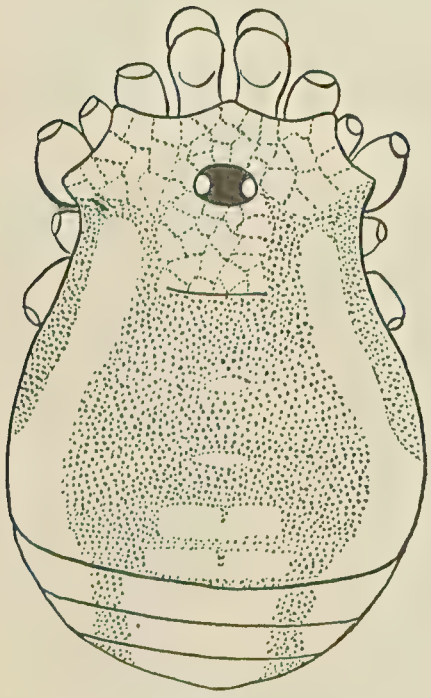
Coxae finely granular but without spines and tubercles. A marginal row of coarse granules in front of and behind coxa III and also behind coxa IV. Respiratory spiracles not concealed. Genital operculum triangular, 0·27 mm. wide at the base and 0·19 mm. long. Penis (figs. 38 and 39) 0·65 mm. long, the trunk portion narrow at the base and increasing in width distally. The glans terminates in a curved hook and is provided with two small setae at each side.

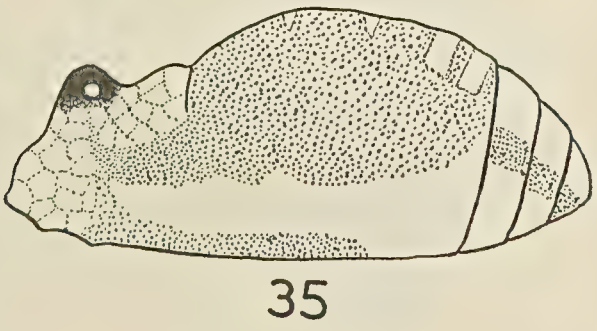
Legs unarmed. The first leg (fig. 40) with a small tubercle below the trochanter and two small tubercles below the femur. Calcaneus small and knob-like. Tarsal formula 3, 3, 4, 4. Distitarsi I and II each with two segments.

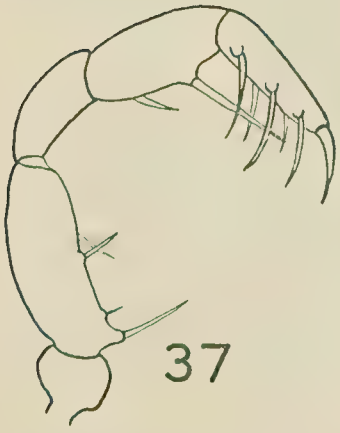
Allotype Female

Measurements in millimeters: Body-length 1·66, length of scutum 1·45, length of carapace 0·57

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·41	0·18	0·52	0·27	0·38	0·44	0·47	2·27
Leg 2	0·45	0·19	0·73	0·34	0·56	0·56	0·63	3·46
Leg 3	0·38	0·19	0·59	0·33	0·45	0·52	0·41	2·87
Leg 4	0·52	0·23	0·77	0·40	0·63	0·71	0·47	3·73
Pedipalp	0·26	0·19	0·56	0·37	0·66	....	0·47	2·51







Lomanella exigua sp. n.

FIG. 34.—Dorsal view of scutum and free tergites of male.
FIG. 35.—Lateral view of scutum and free tergites of male.
FIG. 36.—Retrolateral view of chelicera of male.
FIG. 37.—Retrolateral view of pedipalpus of male.
FIG. 38.—Ventrolateral view of penis.
FIG. 39.—Lateral view of distal part of penis.
FIG. 40.—Leg I of male.

KEY TO SPECIES OF *ANKYLONUNCIA*

1. Tergal grooves on scutum distinct .... *A. fallax* sp. n.
   Tergal grooves on scutum indistinct 2
2. Dorsal spinules on first cheliceral segment numerous .... *A. mestoni* sp. n.
   Dorsal spinules on first cheliceral segment not numerous .... *A. barrowensis* sp. n.

ANKYLONUNCIA FALLAX sp. n.

(Figures 41-45)

Holotype Male

Measurements in millimeters: Body-length 2·63, length of scutum 2·17, length of carapace 1·26.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·86	0·34	1·14	0·57	0·86	1·08	0·86	5·71
Leg 2	1·14	0·40	1·54	0·69	1·20	1·54	1·60	8·11
Leg 3	0·86	0·34	0·97	0·51	0·74	1·03	0·91	5·36
Leg 4	1·14	0·46	1·37	0·74	1·20	1·71	1·14	7·76
Pedipalp	0·74	0·40	1·14	0·69	0·91	....	0·86	4·74

Colour (in alcohol): Scutum light-brown marked with dark-brown as shown in fig. 41. Legs light-brown with dark-brown bands on femora, patellae and tibiae. Chelicerae, pedipalpi and ventral surface of coxae marked with dark-brown reticulations. Genital operculum light-brown with a dark area in the middle. Free tergites dark-brown. Free sternites with a median and two lateral patches of dark-brown on a light-brown ground colour.

Scutum unarmed but with a row of about five minute granules above the anterior margin on each side of the carapace. Eyemound low, wider than high, unarmed and sloping gently up from the front margin. Behind the eyemound the carapace is furnished with 10 granules arranged in two longitudinal rows, five in each row. The scutal groove and tergal grooves well marked. The tergal Areas and free tergites each marked with a transverse row of smooth rounded granules or tubercles (figs. 42 and 43).

Chelicerae large and strong. Dorsal surface of first segment with three small conical tubercles at the apex and a transverse row of three small tubercles across the middle of the segment immediately in front of the dorsal depression. Another small tubercle is present on the prodorsal margin in the distal half of the segment, and also on the retrodorsal margin. The dorsal surface of the second segment is coarsely tuberculate and has three short teeth on the prodorsal margin.

Pedipalpi (fig. 44) moderately robust. Trochanter with two small tubercles above and below. Femur with a median dorsal row of four small teeth and several tubercles. Prolateral surface with a group of three teeth in the distal third. Retrolateral surface with a row of five small tubercles below. Ventral surface with a large proximal tooth and a row of three retroventral teeth, of which the first is the largest and the other two very small. The proventral margin is furnished with a row of five small tubercles. Patella unarmed. Tibia armed with three teeth on each side, the distal tooth on the prolateral side being the largest. Ventral surface with a few tubercles in the basal half. The tarsus has three prolateral and four retrolateral teeth, the first prolateral tooth being moderately large and the first retrolateral tooth very small. The claw is about $\frac{2}{3}$ the length of the segment.

All coxae finely granulate. Front margin of coxa I is armed with two teeth, the apical tooth being bifid. Coxa II with a group of coarse tubercles behind the apex and two above. Coxa III with a marginal row of granules in front and behind. Coxa IV with a group of coarse tubercles in front of the apex and a row af granules along the posterior margin.

Genital operculum smooth, 0·40 mm. long and 0·40 mm. wide. The sternum is long and narrow. The respiratory spiracles are not concealed by the fourth coxae. Between the spiracles there is a pair of conspicuous depressions on the sternite.

Legs rather short and stout. They are unarmed but the femora and tibiae are somewhat tuberculate. The calcaneus of leg I is notched below and forms slightly more than 2/5 the length of the segment (fig. 45). The calcaneus of leg II is straight and makes up about 4/13 the length of the metatarsus. The number of segments in tarsi I-IV is 3, 7, 4, 4. Distitarsi I and II have two and three segments respectively. Claws of tarsi III and IV are three-pronged, the middle prong being the longest.

Allotype Female

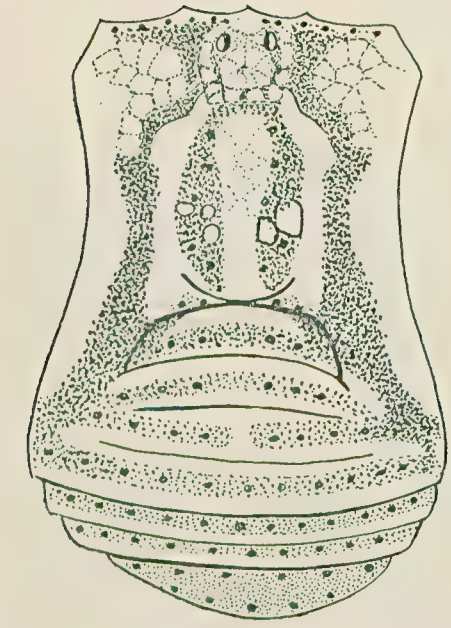
Measurements in millimeters: Body-length 3·43, length of scutum 2·40, length of carapace 1·26.

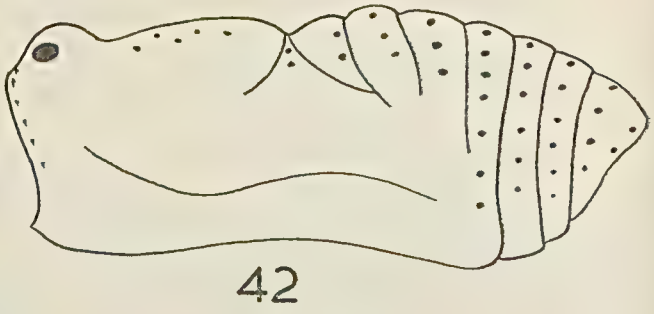
	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·80	0·34	1·09	0·57	0·74	0·97	0·80	5·31
Leg 2	0·97	0·40	1·26	0·68	1·03	1·31	1·49	7·14
Leg 3	0·86	0·40	0·97	0·57	0·74	0·97	0·80	5·31
Leg 4	1·03	0·46	1·43	0·40	1·14	1·54	0·97	6·97
Pedipalp	0·46	0·46	0·97	0·63	0·69	....	0·74	3·95

The female resembles the male in colouration and general appearance. There is little difference in size and the pedipalpi are not much smaller than those of the male. The calcaneus of leg I, however, is straight and not notched below. It makes up about $\frac{1}{3}$ of the length of metatarsus I. The calcaneus of leg II forms about $\frac{1}{3}$ the length of metatarsus II. The number of segments in tarsi I-IV is 3, 7L 6R, 4, 4. The genital operculum measures 0·40 mm. long and 0·51 mm. wide.

Localities: The type specimens were collected from moss at Tunnack, Tasmania, 18th August, 1954. The species is widely distributed but does not appear to be very common. The collection contains specimens from Eaglehawk Neck, Highcroft, Bronte Park and near Swan Bay at the Great Lake.

Variations: Only five males and five females are in the collection examined. The males vary in length from 2·61-2·96 mm. and the females from 2·78-3·43. The number of segments in tarsus I in both sexes is three. In tarsus II the number of segments varies in the males from six to nine and in the females from six to seven.





Ankylonuncia fallax gen. et sp. n.

FIG. 41.—Dorsal view of scutum and free tergites of male.
FIG. 42.—Lateral view of scutum and free tergites of male.
FIG. 43.—Anterior view of eyemound.
FIG. 44.—Prolateral view of pedipalpus of male.
FIG. 45.—Metatarsus and tarsus of leg I of male.

ANKYLONUNCIA MESTONI sp. n.

(Figures 46-50)

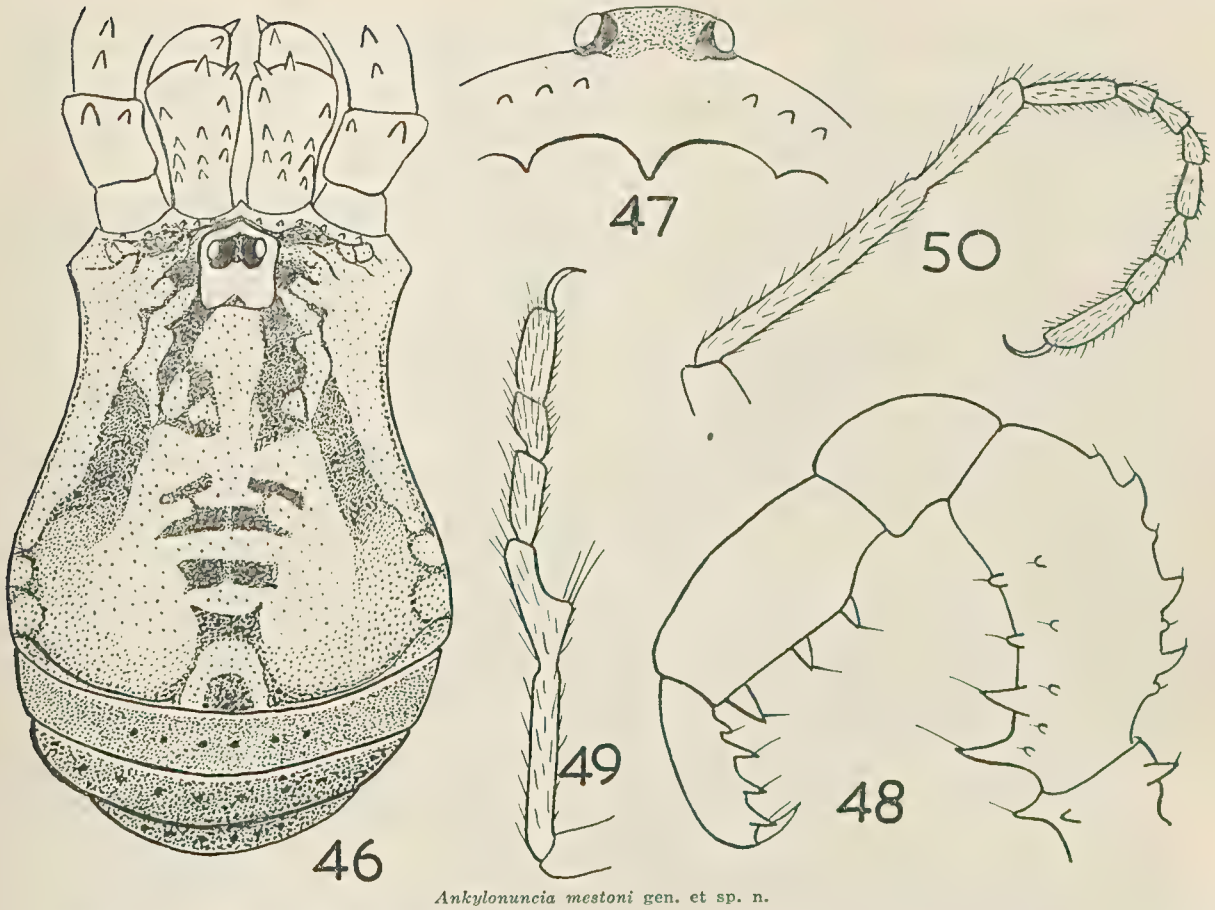
Holotype Male

Measurements in millimeters: Body-length 4·11, length of scutum 3·20, length of carapace 1·60.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·80	0·46	1·62	0·70	1·10	1·39	1·04	7·11
Leg 2	1·37	0·57	2·15	0·93	1·51	2·03	2·20	10·76
Leg 3	1·03	0·51	1·33	0·58	0·99	1·33	1·04	6·81
Leg 4	1·37	0·63	1·91	0·87	1·51	2·20	1·57	10·06
Pedi-palp	0·63	0·57	1·45	0·99	1·10	....	1·16	5·90

Colour (in alcohol): Scutum light-brown with dark markings. On each side the carapace is marked with dark veinings. A pair of irregular dark-brown patches behind the eyemound. Tergal Areas each marked with a short dark transverse bar. The bars lie in a median V-shaped area extending from the scutal groove to the posterior margin of the scutum and between the light-brown lobes of a large saddle-shaped region on the posterior half of the scutum. On each side the light-brown region merges into dark brown. The free tergites and sternites are dark-brown. Palpi, chelicerae and legs light-brown with dark reticulations. Ventral surface of coxae light-brown with dark reticulations.

Scutum smooth and unarmed. A row of about six small granules above the anterior margin on each side of the carapace. The eyemound low, rounded and unarmed. It is situated about half its length from the front margin. Length of carapace half that of the dorsal scute. Tergal grooves indistinct. Each tergal Area with a few minute granules in a short transverse row not extending onto the sides of the scutum. Each free tergite with a transverse row of minute granules (figs. 46 and 47).



Ankylonuncia mestoni gen. et sp. n.

FIG. 46.—Dorsal view of scutum and free tergites of male.
FIG. 47.—Anterior view of eyemound.
FIG. 48.—Retrolateral view of pedipalpus of male.
FIG. 49.—Metatarsus and tarsus of leg I of male.
FIG. 50.—Metatarsus and tarsus of leg II of male.

Chelicerae stout. Basal segment 1·03 mm. long, with a median and a prodorsal tooth at the apex and about 10 small conical teeth on the dorsal surface between apex and base (fig. 46). There is no proximal boss on the retrodorsal margin. The second segment measures 1·49 mm. long and is coarsely tuberculate on the dorsal surface. It has a prodorsal row of three small teeth.

Pedipalpi (fig. 48) moderately strong. Coxa with two small teeth below the apex. Trochanter with a transverse row of three small teeth below and two teeth above. Femur armed with a median dorsal row of four teeth, a small tubercle being present behind each of the first three teeth. Retrolateral surface with a lower row of five small rounded granules. Prolateral surface with a single tooth and three small tubercles in the distal third. Ventral surface with a large proximal tooth, a retroventral row composed of a large tooth and two small teeth, and a proventral row composed of five small tubercles. Patella unarmed. Tibia with three teeth on each side, the distal prolateral tooth being the largest. Ventral surface is granulate. Tarsus with three prolateral and four retrolateral teeth. Claw about $\frac{1}{3}$ the length of the segment.

Coxa I with a row of three small teeth in front, the apical tooth being the largest and bifid. Coxa II coarsely tuberculate behind the apex and with two stout tubercles above. Coxa III with a marginal row of granules in front and behind. Coxa IV with a few small tubercles in front near the apex and a row of granules along the posterior margin.

Genital operculum smooth with rounded margin and clothed with a few hairs. It measures 0·51 mm. long and 0·57 mm. wide. The sternum long and narrow. Respiratory spiracles moderately large and not concealed by the fourth coxae. Free sternites smooth.

Legs unarmed but slightly tuberculate on the femora. The metatarsi exhibit pseudosegmentation. The calcaneus of leg I (fig. 49) notched below and forming $\frac{3}{8}$ of the length of the metatarsus. The calcaneus of leg II (fig. 50) straight and forming $\frac{1}{3}$ of the length of metatarsus II. The number of segments in tarsi I-IV is 3, 9L 8R, 4, 4. Distitarsi I and II have two and three segments respectively. Claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

Locality: The holotype was found at Eaglehawk Neck by A. L. Meston, 23rd February, 1940, and was the only specimen collected.

ANKYLONUNCIA BARROWENSIS sp. n.
(Figures 51-55)

Holotype Male

Measurements in millimeters: Body-length 4·23, length of scutum 3·43, length of carapace 1·66.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·86	0·46	1·88	0·69	1·26	1·71	1·20	8·06
Leg 2	1·43	0·46	2·46	1·03	1·83	2·28	2·57	12·06
Leg 3	1·26	0·51	1·60	0·86	1·14	1·71	1·26	8·34
Leg 2	1·66	0·57	2·11	1·09	1·71	2·28	1·43	10·85
Pedipalp	0·80	0·57	1·94	1·20	1·37	....	1·09	6·97

Colour (in alcohol): Reddish-brown with dark reticulations on each side of the carapace. A pair of dark-brown patches is situated behind the eyemound. A median dark V-shaped mark, crossed by a short dark bar on each tergal Area, extends from the scutal groove to the first free tergite. Chelicerae and pedipalpi reddish-brown with dark reticulations. Legs mainly dark-brown speckled with reddish-brown, except the tarsi, which are greyish. The free tergites and sternites mainly dark-brown.

Scutum (fig. 51) unarmed but with a row of small denticles or granules above the anterior margin on each side. A few granules are also present behind the eyemound and near the anterior end of the lateral ridge at each side of the scutum. The eyemound is low, wider than high, unarmed and sloping gently upward and backward from the front margin. It is furnished with one or two small granules. The scutal groove is shallow and the tergal grooves indistinct. Each tergal Area and free tergite has a transverse row of small granules.

Chelicerae stout. The basal segment is 1·15 mm. long and has a median and a prodorsal tooth at the apex. On the retrodorsal margin there is an oblique row of four small tubercles, but a proximal boss is absent. The second segment is 1·71 mm. long and is furnished with a median dorsal row of small tubercles and a row of four small teeth on the prodorsal margin.

Pedipalpi (fig. 52) large and strong. Coxa with two small denticles below the apex. Trochanter with two denticles below and two above. Femur with a median dorsal row of two small tubercles and four teeth, the second tooth being the largest. The retrolateral surface has a row of four tubercles near the ventral margin. The ventral surface is armed with a large proximal tooth and two retroventral teeth, which are not far from the median position. The proventral margin has a row of small tubercles. On the prolateral surface there is a large tooth in the distal half and three small denticles above it. The patella is armed with two small distal proventral teeth. The tibia is tuberculate below and has three teeth on each side, the second tooth on the prolateral side being nearer to the third than to the first tooth. The tarsus has three teeth on each side.

Coxa I has two large teeth on the front margin, one being near the middle, the other at the apex. The middle tooth is the larger and the apical tooth is bifid. Coxa II has a group of about six small tubercles behind the apex. Coxa III is furnished with a marginal row of granules in front and behind. Coxa IV has a group of small tubercles in front of the apex and a row of granules along the posterior margin. All coxae are furnished with small granules on the ventral surface.

The genital operculum is smooth and measures 0·57mm. long and 0·63 mm. wide. The penis has the form shown in fig. 53. The ventral plate is provided with a pair of superior and three pairs of inferior setae. The distal end of the glans is tubular and possesses a number of fine setae which are directed backward.

The sternum is long and narrow. The respiratory spiracles are large and not concealed by the fourth coxae.

Legs unarmed. Trochanters, femora and tibiae slightly tuberculate. All metatarsi exhibit pseudosegmentation. The calcaneus of leg I is slightly notched below and forms $\frac{1}{3}$ of the length of the metatarsus (fig. 54). The calcaneus of leg II is straight and about $\frac{1}{4}$ the length of metatarsus II. The number of segments in tarsi I-IV is 4, 8L 9R, 4, 4. Distitarsi I and II have two and three segments respectively. The claws of tarsi III and IV are three-pronged, the middle prong being longer than the lateral prongs.

Allotype Female

Measurements in millimeters: Body-length 3·65, length of scutum 3·14, length of carapace 1·54.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·74	0·40	1·71	0·74	1·20	1·60	1·14	7·53
Leg 2	1·31	0·46	2·17	0·91	1·60	2·17	2·28	10·90
Leg 3	1·14	0·46	1·37	0·69	1·20	1·54	1·14	7·54
Leg 4	1·37	0·57	1·88	0·97	1·60	2·34	1·43	10·16
Pedipalp	0·63	0·69	1·54	0·97	1·14	....	1·09	6·06

The female resembles the male in colouration but lacks the V-shaped mark on the scutum. The transverse dark bars on the tergal Areas are larger and extend from side to side merging in a large brown region on each side of the scutum. The pedipalpi are smaller than in the male (fig. 55). The calcaneus of leg I is not notched below and forms about 2/7 of the length of the metatarsus. The number of segments in tarsi I-IV is 3,8, 4, 4.

Locality: The type specimens together with three other males and two other females were found under decaying logs in rain-forest near the foot of Mount Barrow, Northern Tasmania, 8th July, 1957.

Variations: The males vary in length from 3·31-4·28 and the females from 3·43-3·65. All the males have four segments and the females three segments in tarsus I. The number of segments in tarsus II varies from eight to ten in males and eight to nine in females.

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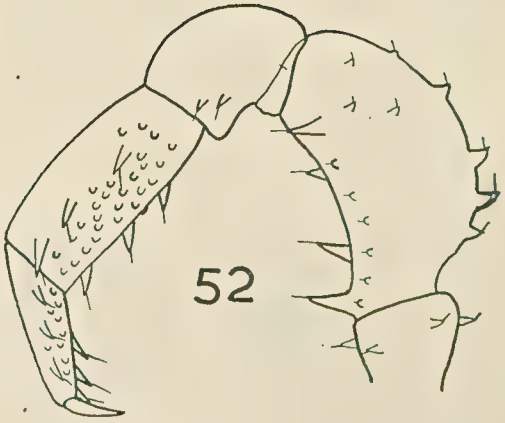

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Ankylonuncia barrowensis gen. et sp. n.

FIG. 51.—Lateral view of scutum and free tergites of male.
FIG. 52.—Prolateral view of pedipalpus of male.
FIG. 53.—Ventral view of distal part of penis.
FIG. 54.—Metatarsus and tarsus of leg I of male.
FIG. 55.—Prolateral view of pedipalpus of female.

Genus **NOTONUNCIA** gen. n.

Carapace provided with a transverse row of granules or small denticles on each side above the anterior margin. Eyemound low, wider than high, unarmed and near the front margin. The tergal Areas and free tergites each provided with a transverse row of granules or small denticles but without spines. First segment of the chelicerae in the male furnished with a proximal retrodorsal boss or condyle. Tarsus of pedipalpus armed with three prolateral and four retrolateral teeth. Legs unarmed. Calcaneus of each metatarsus shorter than astragalus. In males the calcaneus of leg I is notched below. The number of segments in tarsi I-IV in males is 4-6, 11-18, 4, 4, and in females 3-4, 10-16, 4, 4. Distitarsi I and II have two and three segments respectively in both sexes. Claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

Genotype: *Notonuncia diversa* sp. n.

Type Locality: Mount Wellington, Tasmania.

The genus *Notonuncia* is closely related to Holo*nuncia* Forster (1955, p. 387). It differs from that

genus, however, in possessing three instead of four segments in distitarsus II, and also in having a proximal retrodorsal boss on the first segment of the chelicerae of the male. Three new species are placed in the genus and may be distinguished by the following key:

KEY TO SPECIES IN GENUS *NOTONUNCIA*

1. Femur of pedipalp with three ventral teeth .... *N. arvensis* sp. n.
   Femur of pedipalp with four ventral teeth 2
2. Femur of pedipalp with three dorsal teeth .... *N. obscura* sp. n.
   Femur of pedipalp with five or more dorsal teeth .... *N. diversa* sp. n.

NOTONUNCIA DIVERSA sp. n.

(Figures 56-61)

Holotype Male

Measurements in millimeters: Body-length 4·51, length of scutum 3·94, length of carapace 1·66.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	1·03	0·51	2·28	0·97	1·66	2·00	1·43	9·88
Leg 2	1·60	0·63	2·91	1·26	2·34	2·68	3·71	15·13
Leg 3	1·49	0·57	1·94	0·91	1·48	2·23	1·71	10·33
Leg 4	1·77	0·69	2·74	1·14	2·23	3·26	2·00	13·83
Pedipalp	0·80	0·74	2·63	1·54	2·11	....	1·49	9·31

Colour (in alcohol): Scutum yellowish-brown with dark-brown reticulations on each side of the carapace and a pair of triangular dark-brown patches behind the eyemound. A median V-shaped mark extends from the scutal groove to the posterior scutal margin and is crossed by short dark bands on the tergal Areas. Chelicerae and pedipalpi yellowish-brown with dark-brown reticulations. Free tergites and sternites dark-brown. Legs mainly brown, except tarsal segments which are greyish.

Scutum has the form shown in fig. 56. On each side of the carapace there is a row of small granules above the frontal margin. The eyemound (fig. 57) is low, wider than high, unarmed and rising from the anterior margin. There is a small granule behind the eyes and a pair of granules about midway between the eyemound and scutal groove. Tergal grooves indistinct. A transverse row of small granules on each tergal Area, the rows increasing in length posteriorly. On each side of the scutum and above the lateral margin is a longitudinal ridge. Free tergites are unarmed but each has a transverse row of granules.

Chelicerae somewhat stout. Basal segment with two small spincus tubercles at the apex, one of which is median, the other prolateral. On the retrolateral side there is an oblique row of small tubercles and near the proximal end a well formed boss. The second segment is provided with a median dorsal row of small tubercles and a prodorsal row of three small teeth.

Pedipalpi (fig. 58) large and powerful. Trochanter with two small denticles above and below. Femur with a median dorsal row of about seven small teeth, the fourth tooth being the largest. Retrolateral side with a longitudinal row of granules above the ventral margin. Prolateral surface with a tooth near the apex and a few scattered tubercles. Ventral surface with a large proximal tooth, a retroventral row of three large teeth of about the same size, and a proventral row of small tubercles or granules. Patella with a small prolateral tooth near the apex, elsewhere none. Tibia with three small retrolateral teeth, and three larger prolateral teeth, of which the distal tooth is very stout. Ventral surface tuberculate. Tarsus with four retrolateral teeth and three prolateral teeth. Claw about 0·7 mm. long.

Coxae are furnished with a few hairs and small rounded granules on the ventral surface. Coxa I has a row of three small blunt teeth on the front margin, the apical tooth being bifid. Coxa II has a group of about five small tubercles behind the apex. Coxa III is furnished with a marginal row of granules in front and behind. Coxa IV with a group of small tubercles in front of the apex and a posterior row of marginal granules.

Genital operculum smooth, somewhat triangular with rounded sides. It measures 0·40 mm. long and 0·46 mm. wide. The penis has the form shown in fig. 59. The ventral plate is provided with one pair of superior and three pairs of inferior setae. The distal part of the glans is tubular and protected by two wing-like lateral lobes of the dorsal apophysis.

The sternum is long and narrow. The respiratory spiracles are large and not concealed by the last pair of coxae. The free sternites are smooth.

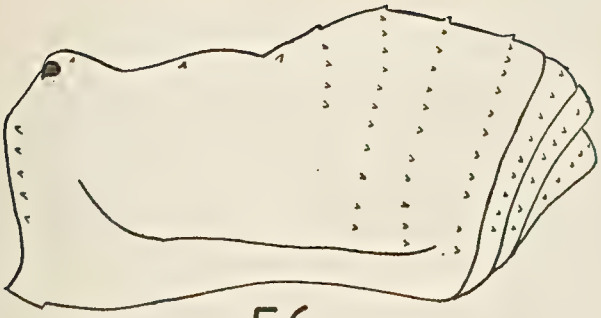
Legs unarmed but the trochanters, femora and tibiae are slightly tuberculate. The calcaneus of leg I is notched below. Its length is about 2/7 that of the metatarsus (fig. 60). All metatarsi exhibit pseudosegmentation. Tarsus I has five segments, tarsus II has 15 on the left and 16 on the right, tarsi III and IV each have four segments. Distitarsi I and II have two and three segments respectively. Claws of tarsi III and IV are three-pronged the middle prong being longer than the lateral prongs.

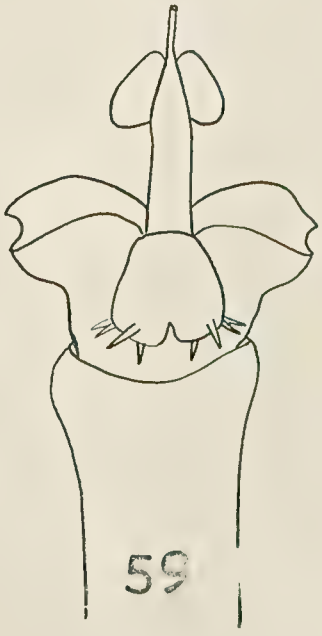
Allotype Female

Measurements in millimeters: Body-length 3·60, length of scutum 3·15, elngth of carapace 1·37.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	To'al
Leg 1	0·74	0·34	1·83	0·74	1·37	1·71	1·31	8·04
Leg 2	1·20	0·40	2·51	0·97	1·94	2·40	3·14	12·57
Leg 3	1·20	0·40	1·71	0·74	1·37	1·94	1·37	8·73
Leg 4	1·54	0·57	2·28	0·97	1·88	2·86	1·71	11·81
Pedipalp	0·57	0·57	1·66	1·08	1·26	....	1·09	6·23

The female is smaller than the male. It resembles it in colour and general appearance. However, it lacks the V-shaped mark on the scutum, which, behind the carapace, is mainly dark-brown, but has a narrow transverse reddish-brown band between tergal Areas IV and V. The pedipalpi (fig. 61) are less robust than in the male and the tibia not so densely tuberculate. The calcaneus of leg I is not notched below and is about 3/13 the length of the metatarsus. The genital operculum is 0·40 mm. long and 0·51 mm. wide.





Notonuncia diversa gen. et sp. n.

FIG. 56.—Lateral view of scutum and free tergites of male.
FIG. 57.—Anterior view of eyemound.
FIG. 58.—Prolateral view of pedipalpus of male.
FIG. 59.—Ventral view of distal part of penis.
FIG. 60.—Metatarsus and tarsus of leg I of male.
FIG. 61.—Prolateral view of pedipalpus of female.

Localities: The type specimens were found on Mt. Wellington, Tasmania, 18th August, 1951. The species also occurs on Mount Dromedary, Mount Hobbs and at Eaglehawk Neck. It is mainly found under decaying logs.

Variations: Males vary in length from 2·5-4·6 mm. and females from 2·5-4·5 mm. There is much variation in the number of segments in tarsi I and II. The distitarsi, however, are remarkably constant. In males tarsus I usually has five segments but may have four or six. In some specimens the segmentation differs in the corresponding tarsi of left and right sides. In the females tarsus I may have either three or four segments. Specimens from Mount Hobbs and Eaglehawk Neck tend to have a smaller number of segments in tarsi I and II than do those from Mount Wellington. Table 5 gives the segmentation of tarsi I and II in the 20 males and 22 females examined.

Table 5

Number of specimens	Sex	Number of segments in tarsus I	Number of segments in tarsus II
2	♂	4	11
2	♂	4	12L 13R
1	♂	4L 5R	13
1	♂	4L 5R	? 13R
1	♂	5	13
1	♂	5	13L 14R
1	♂	5	14
1	♂	5	14L 15R
2	♂	5	14L 16R
1	♂	5	15L ?
1	♂	5	15L 14R
2	♂	5	16L 15R
1	♂	5	16
1	♂	5	17L 16R
1	♂	6L 5R	16
1	♂	6	16L 17R
1	♀	3	10L 11R
2	♀	3	12L 11R
1	♀	3	12
3	♀	3	12L 13R
1	♀	3	12L 14R
2	♀	3	13
1	♀	4	7L 13R
1	♀	4	11
1	♀	4	12L 11R
1	♀	4	12L 13R
2	♀	4	13L 12R
3	♀	4	13
2	♀	4	14L 11R
1	♀	4	14L 13R

NOTONUNCIA ARVENSIS sp. n.

(Figures 62-67)

Holotype Male

Measurements in millimeters: Body-length 5·48, length of scutum 4·57, length of carapace 2·40.

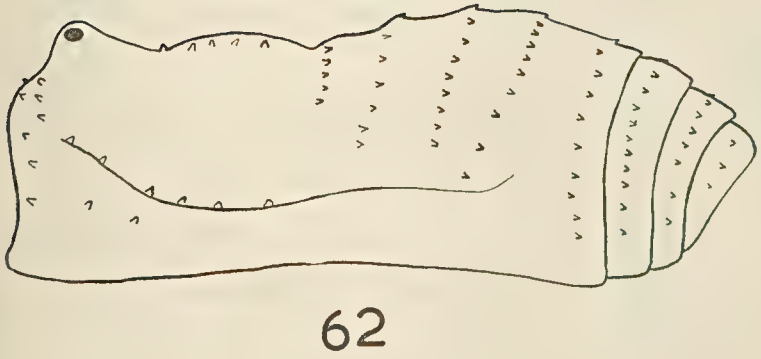
	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	1·03	0·69	3·71	1·37	2·40	2·97	2·00	14·17
Leg 2	2·11	0·74	4·57	1·60	3·26	3·88	4·34	20·50
Leg 3	1·88	0·80	2·86	1·26	2·28	3·26	1·94	14·28
Leg 4	2·28	0·97	3·83	1·60	2·97	4·80	2·28	18·73
Pedipalp	1·03	0·86	3·20	1·71	2·80	....	2·11	11·71

Colour (in alcohol): Scutum reddish-brown. Dark-brown reticulations on each side of carapace. A pair of irregular dark-brown patches behind the eyemound. A median V-shaped dark mark extending from the scutal groove to the posterior margin of the scutum and crossed by a short dark-brown bar on each tergal Area. Chelicerae and pedipalpi reddish-brown with dark reticulations. Legs mainly dark-brown speckled with yellow. Tarsi grey. Ventral surface of body reddish-brown, somewhat darker on free sternites.

Scutum (fig. 62) unarmed. Carapace furnished with an irregular row of granules above the anterior margin on each side. A few granules are also present between the eyemound and the scutal groove, at the sides of the carapace and along the anterior half of the longitudinal lateral ridge of the scutum. Eyemound (fig. 63) low, wider than high, unarmed, situated about half its diameter from the front margin. Scutal groove distinct medianly. Tergal grooves indistinct. Each tergal Area and free tergite with a transverse row of granules or small denticles.

Chelicerae stout. Basal segment 1·43 mm., second segment 2·28 mm. long. Two small teeth are present at the apex of the basal segment, one median, the other prodorsal. On the retrolateral side of the basal segment there is an oblique row of small granules and at the proximal end a small boss. The second segment is large and swollen. It is furnished with a median dorsal row of coarse tubercles and a prodorsal row of three teeth, the middle tooth being the largest.

Pedipalpi (fig. 64) large and strong. Coxa with a transverse row of three denticles below the apex. Trochanter with three denticles above and below. Femur swollen and armed with a median dorsal row of three large teeth. Retrolateral surface has a few small granules. Prolateral surface with a large tooth in the distal quarter and two smaller teeth above it. Ventral surface with a large proximal tooth, in front of which is a second large tooth, whilst a third tooth of almost the same size is present in the distal half and on the retroventral margin. A few small tubercles are present above the proventral margin. The patella has two small prolateral denticles towards the ventral side. The tibia is armed with three teeth on each side. Those on the retrolateral side are very small. Of the three prolateral teeth the second is nearer to the third than to the first and the third tooth is the largest. The ventral surface is tuberculate. The tarsus is armed with three prolateral and four



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Notonuncia arvensis gen. et sp. n.

FIG. 62.—Lateral view of scutum and free tergites of male.
FIG. 63.—Anterior view of eyemound.
FIG. 64.—Prolateral view of pedipalpus of male.
FIG. 65.—Ventral view of distal part of penis.
FIG. 66.—Metatarsus and tarsus of leg I of male.
FIG. 67.—Prolateral view of pedipalpus of female.

retrolateral teeth and there are a few tubercles on the ventral surface. The claw is about 0·7 mm. long.

Coxa I has three short blunt spines on the anterior margin, the distal spine being the largest and bifid. Coxa II has a group of about six small blunt tubercles behind the apex. Coxa III is furnished with a marginal row of granules in front and behind. Coxa IV has a group of about six small blunt tubercles in front of the apex and a row of granules along the posterior margin. The ventral surface of each coxa is provided with small rounded granules.

The genital operculum is smooth. It measures 0·51 mm. long and 0·57 mm. wide. The penis has the form shown in fig. 65. The distal part of the glans is tubular and protected by a pair of large wing-like lobes of the dorsal apophysis. The ventral plate has one pair of superior and three pairs of inferior setae.

The sternum is long and narrow. The respiratory spiracles are large and not concealed by the fourth coxae.

The legs are unarmed but the trochanters, femora and tibiae are slightly tuberculate. All metatarsi exhibit pseudosegmentation. The calcaneus of leg I (fig. 66) is notched below and forms about ¼ of the length of the metatarsus The calcaneus of metatarsus II is straight and about ⅓ the length of the segment. The number of segments in tarsi I-IV is 5, 16, 4, 4. Distitarsi I and II have two and three segments respectively. The claws of tarsi III and IV are three-pronged, the middle prong being longer than the lateral prongs.

Allotype Female

Measurements in millimeters: Body-length 5·37, length of scutum 4·00, length of carapace 1·71.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	1·26	0·69	2·74	1·14	2 00	2·57	1·71	12·11
Leg 2	1·77	0·80	3·54	1·26	2·68	3·20	4·00	17·25
Leg 3	1·71	0·69	2·46	1·09	1·88	2·86	1·71	12·40
Leg 4	2·00	0·86	3·14	1·31	2·57	4·11	1·88	15·87
Pedipalp	0·74	0·74	2·23	1·26	1·71	....	1·60	8·28

The female resembles the male in colouration and general appearance. However, it lacks the median V-shaped mark on the tergal region of the scutum and the pedipalpi are smaller and less robust (fig. 67). The calcaneus of leg I is straight and not notched below. It forms about 1/6 the length of the metatarsus. The number of segments in tarsi I-IV is 4, 14L 15R, 4, 4. The genital operculum measures 0·51 mm. long and 0·63 mm. wide.

Localities: The type specimens were found in the Arve Forest, Geeveston, Tasmania, 11th November, 1955. Other specimens in the collection come from near the Ida Bay Caves at Hythe and a single specimen is from Mount Wellington.

Variations: Males vary in length from 4·9-5·5 mm. and females from 4·8-5·9 mm. The collection contains five males and six females. The males all have five segments in tarsus I, and the females four. The number of segments in tarsus II varies as shown in Table 6.

Table 6

Number of specimens	Sex	Number of segments in tarsus I	Number of segments in tarsus II
1	♂	5	?L 14R
1	♂	5	15
1	♂	5	16L 15R
1	♂	5	16
1	♂	5	18L 17R
2	♀	4	13L 12R
1	♀	4	13
1	♀	4	13L 14R
1	♀	4	14L 15R
1	♀	4	16L 14R

The distitarsi I and II have two and three segments respectively in all the specimens.

NOTONUNCIA OBSCURA sp. n.

(Figures 68-72)

Holotype Male

Measurements in millimeters: Body-length 4·40, length of scutum 3·26, length of carapace 1·43.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	1·14	0·40	1·77	0·80	1·26	1·54	1·26	8·17
Leg 2	1·37	0·51	2·40	0·91	1·71	2·11	2·46	11·47
Leg 3	1·26	0·46	1·60	0·74	1·20	1·60	1·26	8·12
Leg 4	1·54	0·57	2·17	0·97	1·71	2·46	1·31	10·73
Pedipalp	0·86	0·46	1·88	1·09	1·54	....	1·26	7·09

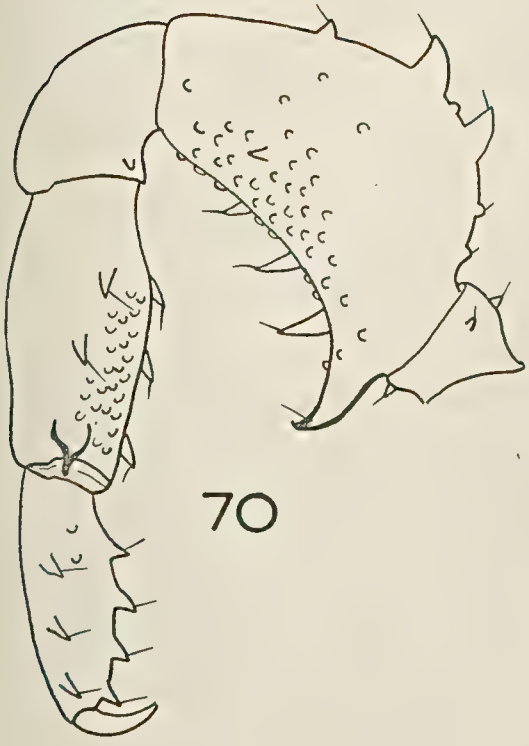
Colour (in alcohol): Scutum reddish-brown with dark reticulations on each side of the carapace. Between the eyemound and the reticulations on each side is a dark triangular patch. The two patches unite along the front margin anterior to the eyemound. A pair of irregular dark-brown areas is situated close behind the eyemound and a larger dark-brown region occurs on each side of the scutum. A median elongate V-shaped dark mark extends from the scutal groove to the posterior margin of the first free tergite. Chelicerae and pedipalpi reddish-brown with dark reticulations. Legs mainly dark-brown speckled with reddish-brown. Tarsi grey. Ventral surface of body reddish-brown.

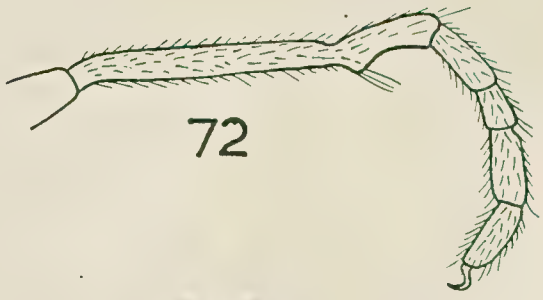
Scutum (fig. 68) unarmed. A row of small denticles or granules above the anterior margin on each side of the carapace. A few granules are also present near the anterior end of the lateral ridge on each side of the scutum and also immediately behind the eyemound. The scutal groove is distinct medianly but the tergal grooves are indistinct. A transverse row of granules is present on each tergal Area and free tergite. The eyemound (fig. 69) is low, wider than high, situated slightly behind the anterior margin and sloping gently towards the front.

Chelicerae stout and strong. The basal segment is 0·91 mm. long, armed at the apex with a short median tooth and a smaller prodorsal tooth. On

the retrodorsal margin there is a row of small tubercles and towards the base a small proximal boss. A few granules are also present on the prodorsal margin. The second segment is 1·43 mm. long, somewhat swollen and furnished with a median dorsal row of tubercles and a prodorsal row of three teeth.

Pedipalpi (fig. 70) large and strong. Coxa with a transverse row of three teeth below the apex, the median tooth being larger than the other two. Trochanter with two teeth above and below. Femur with a dorsal median row of three teeth and several granules. The first tooth in the row is the largest. Retrolateral surface with a row of granules above the retroventral teeth. Prolateral surface without large teeth but with a number of tubercles. Ventral surface with a large proximal tooth, which slopes backwards and is curved slightly forwards at the tip. A row of three large teeth is present on the retroventral





Notonuncia obscura gen. et sp. n.

Fig. 68.—Lateral view of scutum and free tergites of male.
Fig. 69.—Anterior view of eyemound.
Fig. 70.—Prolateral view of pedipalpus of male.
Fig. 71.—Ventral view of distal part of penis.
Fig. 72.—Metatarsus and tarsus of leg I of male.

margin. No teeth are found on the proventral margin but the ventral surface is tuberculate. Patella unarmed. Tibia with three teeth on each side. The distal tooth on the prolateral side is very stout. Ventral surface tuberculate. Tarsus with three prolateral and four retrolateral teeth. Ventral surface almost without tubercles. Claw nearly half as long as the segment.

Coxa I with three small blunt teeth on the anterior margin, the apical tooth being the largest and slightly bifid. Coxa II with a group of about six small blunt tubercles behind the apex. Coxa III with a marginal row of granules in front and behind. Coxa IV with a group of about six small blunt tubercles in front of the apex and a row of granules on the posterior margin. Ventral surface of each coxa furnished with small scattered rounded granules.

Genital operculum smooth, 0·46 mm. long and 0·51 mm. wide. The penis has the form shown in fig. 71. The ventral plate is provided with one pair of superior and three pairs of inferior setae. The distal end of the glans is not fully extended and is concealed between the paired lobes of the dorsal apophysis.

The sternum is long and narrow. Respiratory spiracles large and not concealed by the fourth coxae.

The legs are unarmed but trochanters, femora and tibiae somewhat tuberculate. All metatarsi exhibit pseudosegmentation. Calcaneus of leg I notched below (fig. 72). It forms about 1/3 of the length of the first metatarsus . The calcaneus of the second metatarsus is straight and about 2/7 the length of the segment. The number of segments in tarsi I-IV is 4, 13L 12R, 4, 4. Distitarsi I and II have two and three segments respectively. Claws of tarsi III and IV are three-pronged, the middle prong being longer than the lateral prongs.

Locality: The holotype male and three other male specimens were found under logs in *Notofagus* forest near the entrance to the Hastings Caves, Tasmania, 5th December, 1952. No female specimens were found.

Variations: The four males vary in length from about 3·5-4·4 mm. Each has four segments in tarsus I. The number of segments in tarsus II varies from 11-13.

Genus **TASMANONUNCIA** gen. n.

Eyemound smooth, rounded and unarmed; situated in the anterior third of the carapace. Scutum unarmed except for a single conical tooth above the front margin on each side of the carapace. Scutal groove distinct medianly; other tergal grooves absent. Tergal Areas and free tergites without spines and tubercles. First segment of chelicerae of male without a proximal retrodorsal boss. Proximal median ventral tooth on femur of pedipalpus in male not bifid. Calcaneus of each metatarsus much shorter than astragalus. Calcaneus of leg I of male not notched below. Tarsal segmentation: 3, 5-7, 4, 4. Distitarsi I and II with two and three segments respectively. Claws of tarsi III and IV three-pronged, the middle prong being larger than the lateral prongs.

Genotype: *Tasmanonuncia segnis* sp. n.

Type Locality: Trevallyn, Launceston, Tasmania.

The genus *Tasmanonuncia* is close to *Psalenoba* Roewer (1931, p. 159) but differs from that genus in the shape of the eyemound and in the presence of a tooth above the anterior margin on each side of the carapace.

TASMANONUNCIA SEGNIS sp. n.

(Figures 73-79)

Holotype Male

Measurements in millimeters: Body-length 1·94, length of scutum 1·65, length of carapace 0·86.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·51	0·23	0·74	0·34	0·51	0·65	0·48	3·46
Leg 2	0·79	0·25	0·97	0·40	0·80	0·91	0·91	5·03
Leg 3	0·57	0·23	0·69	0·37	0·57	0·74	0·48	3·65
Leg 4	0·74	0·29	0·91	0·46	0·74	1·05	0·57	4·76
Pedipalp	0·34	0·23	0·97	0·51	0·57	....	0·57	3·19

Colour (in alcohol): The scutum has yellow and brown markings. A large saddle-shaped yellow area occurs on the posterior half of the scutum (fig. 73). The pedipalpi are yellowish-brown with dark reticulations. Free tergites and legs brown. Ventral surface of body light-brown.

Scutum (fig. 73) has a finely shagreened surface. The eyemound is low, rounded and unarmed (fig. 74). It is situated about half its diameter from the front margin. Above the anterior margin on each side of the carapace and about midway between the eyemound and the lateral angle is a conical tooth. Tergal grooves are absent. The tergal Areas and free tergites are devoid of tubercles and spines.

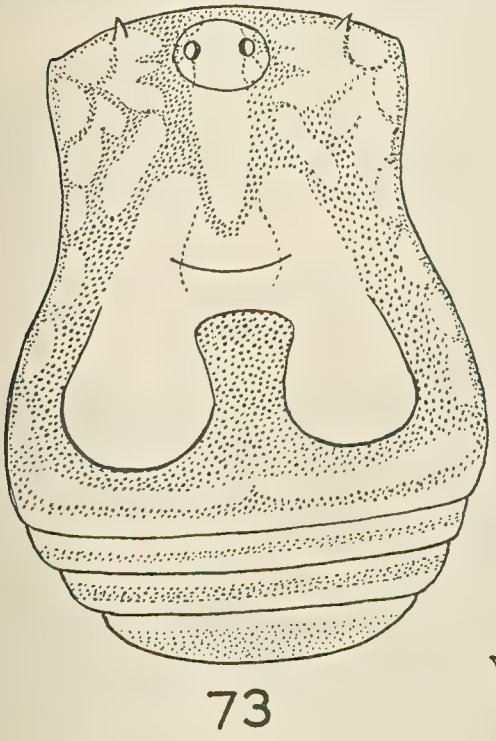
Chelicerae (fig. 75) moderately strong. The basal segment is 0·57 mm. long and has a median dorsal tooth near the apex. A retrodorsal boss is absent. The second segment is 0·74 mm. long and is armed with a prodorsal row of three teeth, the middle tooth being the largest. Two other teeth are present in the median line.

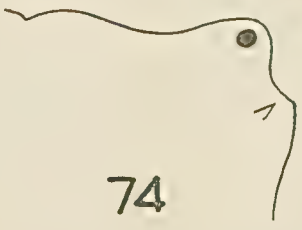
Pedipalpi (fig. 76) strong. Trochanter with a small tooth above and below. Femur arched dorsally and, in the proximal half, enlarged in a dorsoventral direction, its greatest dorsoventral diameter being about 5/8 of its length. It is furnished with a median dorsal row of six small teeth and a prodorsal row of small tubercles. The prolateral surface has two teeth in the distal quarter. The retrolateral surface is provided with a row of small tubercles above the retroventral margin. The ventral surface is armed with a median proximal tooth, a promarginal row of four tubercles and a retromarginal row of four teeth, the first of which being the largest. The patella has two prolateral tubercles. The tibia is tuberculate below and armed with two prolateral and three retrolateral teeth. The tarsus has four retrolateral and three prolateral teeth, the first retrolateral tooth being very small.

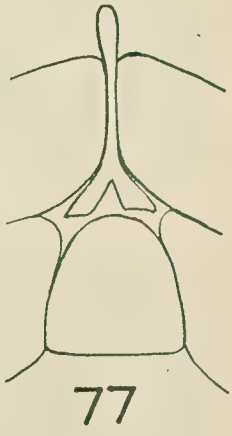
Coxa I smooth and polished, with two small blunt teeth on the front margin, the apical tooth being bifid. The other coxae are finely shagreened.

Coxa II has two small teeth behind the apex and a narrow elongate tubercle on the dorsal surface. Coxa III is furnished with a marginal row of four or five granules in front and behind. Coxa IV with a few bridging granules on the posterior margin covering the respiratory spiracle.

Sternum (fig. 77) long and narrow. Genital operculum rounded in front, finely shagreened, and measuring about 0·22 mm. long and 0·23 mm. wide. The penis when fully extended has the form shown in fig. 78. The ventral plate has a deep marginal cleft and is armed with two pairs of superior and







Tasmanonuncia segnis gen. et sp. n.

Fig. 73.—Dorsal view of scutum and free tergites of male.
Fig. 74.—Lateral view of eyemound.
Fig. 75.—Prolateral view of chelicera of male.
Fig. 76.—Prolateral view of pedipalpus of male.
Fig. 77.—Sternum and genital operculum of male.
Fig. 78.—Lateral view of penis.
Fig. 79.—Leg I of male.

three pairs of inferior setae. On each side of the glans is a large sickle-shaped lateral porcess. The distal end of the glans is somewhat blunt and is covered by a two-lobed dorsal apophysis.

The respiratory spiracles are partly concealed under the bridging granules on the posterior margin of the fourth coxae.

Legs unarmed and shagreened. The femur of leg I (fig. 79) has two small rounded tubercles below the basal quarter. The calcanei are short and conical. The number of segments in tarsi I-IV is 3, 5, 4, 4. Distitarsi I and II have two and three segments respectively. Claws of tarsi III and IV are three-pronged, the middle prong being the largest.

Allotype Female

Measurements in millimeters: Body-length 1·83, length of scutum 1·43, length of carapace 0·68.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·40	0·20	0·65	0·34	0·46	0·57	0·46	3·08
Leg 2	0·63	0·24	0·91	0·42	0·74	0·86	0·86	4·66
Leg 3	0·51	0·23	0·69	0·34	0·55	0·68	0·48	3·48
Leg 4	0·69	0·28	0·86	0·40	0·74	0·97	0·59	4·53
Pedipalp	0·34	0·23	0·69	0·40	0·46	....	0·40	2·52

The female resembles the male in colouration but the yellow saddle-shaped area on the scutum is much smaller. The teeth on the dorsal surface of the second segment of the chelicerae are also smaller. The pedipalpi are shorter and less robust than those of the male. The tibia is not so strongly granulate below. Tarsal segmentation: 3, 5, 4, 4.

Localities: The type specimens were found near Treyallyn, Launceston, Tasmania, 29th January, 1945. Other specimens were collected at places near Launceston, notably Distillery Creek, Punch Bowl and Exeter. The harvestman occurs in moss or under stones and fallen logs.

Variations: Males vary in length from 1·2-2·1 mm. and females from 1·4-2·2 mm. Seventeen males and 22 females are contained in the collection. All have three segments in tarsus I and four segments in tarsi III and IV. The number of segments in tarsus II varies in the males from 5-7 and in the females from 5-6. Eight males and 21 females have a tarsal segmentation of 3, 5, 4, 4. Five males and one female exhibit asymmetry in the number of segments in tarsus II on left and right sides of the body.

Genus LEIONUNCIA gen. n.

Carapace shorter than scutum. Frontal margin furnished above on each side with a row of minute tubercles or denticles. The eyemound is low and smooth; situated in the anterior third of the carapace. Tergal Areas I-V and the free tergites unarmed, but provided with a transverse row of minute tubercles or granules. Basal segment of chelicerae with a small proximal boss on the retrodorsal margin. Legs unarmed. Trochanters, femora and tibiae somewhat granular. Calcanei shorter than astragali. In both sexes the calcaneus of metatarsus I is straight and without a ventral notch. The segmentation of tarsi I and II is variable. In the male tarsus I has 4-6 segments and tarsus II 12-16. In the female tarsus I has 3-5 segments and tarsus II 9-16. In both sexes tarsi III and IV each have four segments. Distitarsi I and II have two and three segments respectively. Claws of tarsi III and IV are three-pronged, the median prong being larger and stronger than the lateral prongs.

Genotype: *Leionuncia* levis sp. n.

Type Locality: Myrtle Forest, Collinsvale, Tasmania.

Leionuncia is close to *Holonuncia* Forster (1955, p. 387) but differs from the latter genus in that the calcaneus of the first metatarsus of the male is without a ventral notch and the distitarsus of leg II has three instead of four segments.

LEIONUNCIA LEVIS sp. n.

(Figures 80-85)

Holotype Male

Measurements in millimeters: Body-length 3·60, length of scutum 3·14, length of carapace 1·43.

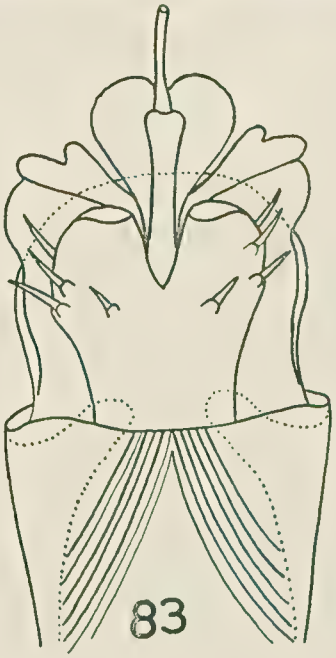
	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	1·03	0·46	1·83	0·80	1·43	1·71	1·37	8·63
Leg 2	1·37	0·46	2·46	1·03	2·00	2·28	3·08	12·68
Leg 3	1·20	0·46	1·77	0·69	1·37	1·83	1·43	8·75
Leg 4	1·43	0·63	2·28	0·97	1·83	2 57	1·60	11·31
Pedipalp	0·69	0·63	2·28	1·26	1·88	....	1·43	8·17

Colour (in alcohol): Chelicerae, pedipalpi, coxae and carapace light-brown with dark-brown reticulate markings. Tergal Areas with short transverse dark-brown bars, which decrease in size posteriorly forming a median wedge-shaped pattern. Free tergites and sternites brown. Legs dark-brown, except the tarsi which are grey.

Scutum (fig. 80) furnished with a row of about five minute tubercles or granules on each side above the frontal margin. The eyemound is low and smooth (fig. 81). It is situated about half its length from the front margin. Behind the eyemound the carapace is distinctly arched longitudinally and provided with a few granules. The first scutal groove is well marked medianly but the other scutal grooves are absent. Tergal Areas II-V each with a transverse row of small granules, the rows increasing in length posteriorly. Above the margin on each side of the scutum is a longitudinal ridge. Each free tergite has a transverse row of small granules. Spines and large tubercles are absent from both the scutum and the free tergites.

Chelicerae short and stout. The basal segment measures 0·97 mm. long and has a small proximal boss on the retrodorsal margin, and two short spines at the apex, one of which is median and the other prolateral. A few small tubercles form an oblique row on the retrodorsal margin of the segment. The second segment is 1·43 mm. long and its dorsal (frontal) surface is tuberculate and has two small teeth on the inner side, one near the middle, the other near the base.

Pedipalpi (fig. 82) large and somewhat elongate. Trochanter with two small teeth above and below. Femur with a dorsal median row of four teeth and several small tubercles. The two teeth near the middle of the row are larger than the others. Prolateral surface and retrolateral surface smooth except for a few scattered granules. Ventral surface with a median proximal tooth and a retroventral row of three teeth, of which the second is small and the third very large and strong. The proventral margin has a row of granules, at the distal end of which is a large tooth. The patella is unarmed. The tibia is somewhat cylindrical but swollen near the middle of its length. It is elongate, being nearly as long as the femur, and has three teeth on each side. The apical tooth on the prolateral side is much larger than the others. The ventral surface is somewhat tuber-



Leionuncia levis gen. et sp. n.

Fig. 80.—Lateral view of scutum and free tergites of male.
Fig. 81.—Anterior view of eyemound.
Fig. 82.—Prolateral view of pedipalpus of male.
Fig. 83.—Ventral view of distal part of penis.
Fig. 84.—Metatarsus and tarsus of leg I of male.
Fig. 85.—Prolateral view of pedipalpus of female.

culate. The tarsus has three prolateral teeth and four retrolateral teeth. The first tooth on the retrolateral side is minute. The claw is about one-third the length of the segment.

Coxa I has two small teeth on the front margin, one near the middle, the other near the apex. The apical tooth is bifid. Coxa II has a few small tubercles behind the apex. Coxa III is provided with a marginal row of granules in front and behind. Coxa IV has about five small tubercles in front of the apex and a row of granules along the apical half of the posterior margin.

The genital operculum is smooth and rounded in front and at the sides. It measures 0·4 mm. in width and length. The penis has the form shown in fig. 83. The ventral plate is deeply cleft and has three pairs of interior and one pair of superior setae. The distal part of the glans is produced into a narrow tube, which lies between the two leaf-like lobes of the dorsal process. Behind the dorsal process are the lateral apophyses, one on each side. The dorsal plate is large and rounded.

The sternum is long and narrow. Its posterior end is not crescentic. The respiratory spiracles are oval and not concealed by the fourth coxae.

The legs are unarmed but the femora, patellae and tibiae are coarsely granulate. The calcaneus of metatarsus I is straight and not notched below (fig. 84). It is slightly more than ¼ the length of the segment. The calcaneus of metatarsus II is ¼ the length of the segment. Tarsus I has five segments, tarsus II has 12 segments on the right and 13 on the left leg, tarsi III and IV each have four segments. Distitarsi I and II have two and three segments respectively. The claws of tarsi III and IV are three-pronged, the middle prong being larger and stronger than the lateral prongs.

Allotype Female

Measurements in millimeters: Body-length 3·83, length of scutum 2·74, length of carapace 1·31.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·74	0·40	1·66	0·74	1·31	1·54	1·20	7·59
Leg 2	1·14	0·51	2·28	1·03	1·83	2·00	3·31	12·10
Leg 3	1·03	0·46	1·54	0·74	1·26	1·54	1·26	7·83
Leg 4	1·31	0·57	2·17	0·86	1·71	2·40	1·66	10·68
Pedipalp	0·63	0·46	1·77	0·97	1·66	....	1·20	6·69

The female resembles the male in general appearance and colour. The pedipalpi (fig. 85), however, are smaller than those of the male and the distal tooth in the retroventral row on the femur is not so large. The tubercles below the tibia are less numerous. The genital operculum is wider than that of the male. Tarsal segmentation: 4, 12, 4, 4. Distitarsi as in the male.

Localities: The holotype and allotype were found under decaying logs at Myrtle Forest, Collinsvale, Tasmania, on 8th November, 1955. The species also occurs at Hastings, the Arve Forest, Mount Wellington, National Park, Tarraleah and Bronte Park. Adult specimens of both sexes may be found during both summer and winter.

Variations: The collection under examination contains 92 specimens of *Leionuncia levis*, of which 38 are males and 54 females. The species is extremely variable in the segmentation of tarsi I and II. It is rare to find two individuals with the same tarsal segmentation even in the one locality. The species also exhibits considerable asymmetry in the number of segments in tarsus II on left and right sides of the body. There is also some asymmetry in tarsus I, especially in the males. See Table 7, which gives the segmentation of tarsi I and II in the 92 specimens examined.

Table 7

Number of specimens	Sex	Number of segments in tarsus I	Number of segments in tarsus II
1	♂	4	12L 13R
2	♂	4	13
1	♂	4	14L 12R
1	♂	4	14L 13R
1	♂	4	14L 16R
1	♂	4L 5R	12L 13R
1	♂	4L 5R	13
2	♂	4L 5R	13L 14R
2	♂	4L 5R	14L 13R
1	♂	4L 5R	14L 15R
1	♂	4L 5R	15L 13R
1	♂	5	12
1	♂	5	13
2	♂	5	13L 14R
1	♂	5	13L 15R
1	♂	5	14L 12R
1	♂	5	14L 13R
3	♂	5	14
2	♂	5	14L 15R
2	♂	5	15L 14R
1	♂	5	15
1	♂	5	15L 16R
1	♂	5	16L 14R
2	♂	5	16
1	♂	5L 4R	12L 13R
1	♂	5L 6R	15L 14R
1	♂	6L 5R	14L 12R
1	♂	6L 5R	15L 14R
1	♂	6L 5R	15
1	♀	3L 4R	11L 12R
9	♀	4	11
3	♀	4	12
4	♀	4	13
3	♀	4	10L 11R
1	♀	4	10L 12R
4	♀	4	11L 12R
1	♀	4	11L 13R
1	♀	4	12L 9R
8	♀	4	12L 11R
2	♀	4	12L 13R
2	♀	4	12L 14R
1	♀	4	13L 11R
5	♀	4	13L 12R
3	♀	4	13L 14R
3	♀	4	14L 13R
1	♀	4	14L 15R
1	♀	4	15L 16R
1	♀	5	12L 13R

Genus **ALLONUNCIA** gen. n.

Eyemound smooth, rounded, unarmed and removed from the anterior margin of the carapace by a distance greater than its transverse diameter. Scutum, free tergites and legs unarmed. First segment of chelicerae of male devoid of a strong boss on the retrodorsal margin. Proximal ventral tooth on femur of pedipalpus of male not bifid. Each calcaneus shorter than astragalus. Calcaneus of leg I of male not notched below. Tarsi I, III and IV each with four segments. Tarsus II variable with 10-15 segments. Distitarsus I with two segments. Distitarsus II variable with four to six segments. Claws of tarsi III and IV are three-pronged, the middle prong larger than the lateral prongs.

Genotype: *Allonuncia grandis* sp. n.

Type Locality: Near Lake St. Clair, Tasmania.

ALLONUNCIA GRANDIS sp. n.

(Figures 86-91)

Holotype Male

Measurements in millimeters: Body-length 8·06, length of scutum 5·70, length of carapace 3·40.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	1·67	0·69	3·20	1·25	2·22	2·64	1·52	13·19
Leg 2	2·36	0·83	3·75	1·67	3·48	4·03	4·17	20·29
Leg 3	2·22	0·83	2·64	1·25	2·36	3·61	1·95	14·86
Leg 4	2·78	1·11	3·34	1·67	3·20	4·86	2·64	19·60
Pedipalp	1·39	0·97	5·42	3·06	3·20	....	2·50	16·54

Colour (in alcohol): The general colour of the body and appendages is reddish-brown. Pedipalpi and legs are marked with dark reticulations. Scutum has a light coloured saddle-shaped region behind the carapace, dark reticulations in front of the eyemound and a pattern of radiating lines in an oval area on each side of the anterior third. Behind the eyemound is a rhomboid patch of dark-brown, which merges into a dark-brown area on each side of the scutum.

Dorsal scutum unarmed (fig. 86). Immediately behind the anterior margin is a groove which is continuous laterally with a longitudinal groove on each side of the scutum. Eyemound smooth, rounded and unarmed; set back from the anterior margin by a distance equal to one and a half times its transverse diameter (figs. 87 and 88). First scutal groove faintly marked, second and third distinct in the median region, fourth and fifth well developed and extending from side to side. The fifth groove is very deep. Tergal Areas and free tergites each have a transverse row of rounded granules. The rows on the first three tergal Areas are composed of only a few granules and do not extend very far laterally. Those on the fourth and fifth Areas and on the free tergites extend to the lateral margins.

Chelicerae strong. Basal segment with a large median tooth at the apex on the dorsal surface and a second tooth near the middle of the retrodorsal margin. Dorsal (frontal) surface of second segment with a median tooth near the base, a longitudinal row of three strong teeth on the inner side and a similar row of three weaker teeth on the outer side.

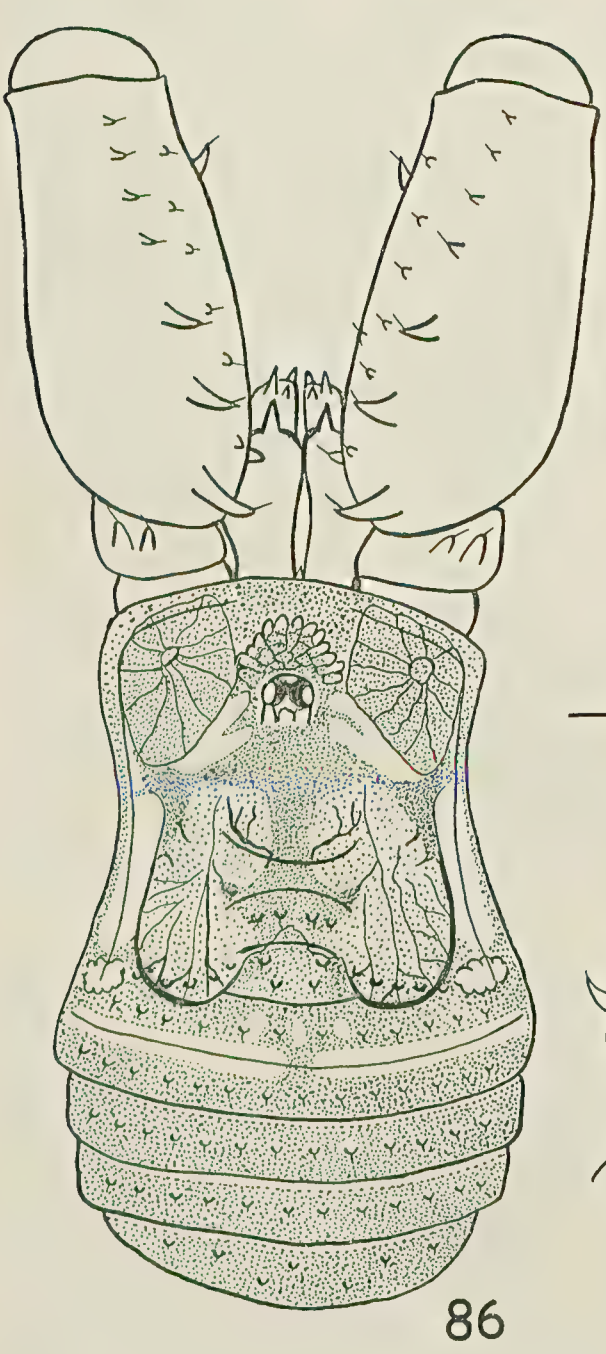
Pedipalpi very powerful and massive. The coxa has two large ventral teeth fused at their bases and a small tubercle on each side of them. Trochanter has a dorsal transverse row of two inner tubercles and two outer teeth. On the lower surface there is a single tooth. The femur is extremely large and swollen. It is almost as long as the dorsal scutum (fig. 86) and posteriorly it bulges backward over the trochanter. The dorsal surface has a median row of seven teeth which decrease in size distally. The teeth curve inwards and the first tooth is the largest. On the prodorsal margin there is an irregular row of small tubercles, below which are several larger tubercles on the prolateral surface. The ventral surface has a very large median tooth at the base, a retroventral row of large teeth and a proventral row of six minute tubercles, the distal one being the largest. The retrolateral surface is smooth. The patella has a single tooth on the prolateral side at the apex. Tibia has three teeth on each side in the distal two thirds, the first tooth on each side being the largest. The tarsus has three short stout teeth on each side. The claw is short being about ¼ the length of the segment (fig. 89).

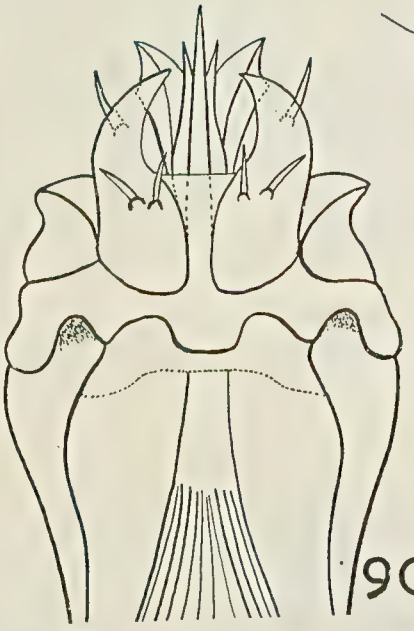
Coxae somewhat granular and clothed with short hairs on the ventral surface. Coxa I has a row of three small teeth on the anterior margin, the first tooth being the largest and near the middle. The other two are small and close together at the apex. Coxa II has two teeth behind the distal third, the larger tooth being near the apex. On the dorsal side an elongated blunt tooth and two rounded granules are present. Coxa III has a marginal row of granules in front and behind. Coxa IV is provided with a conical tubercle and a few granules in front near the apex and a marginal row of about eight granules behind, immediately in front of the respiratory spiracle.

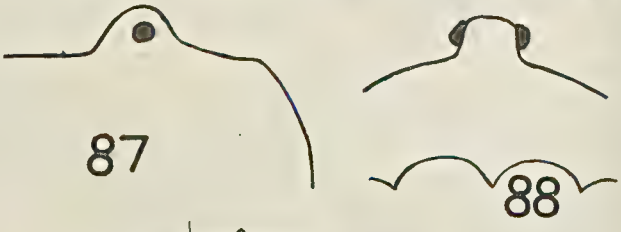
Sternum very narrow, its middle portion being almost hidden by the bases of the third coxae. Genital operculum is rounded in front and wider than long. The margin is smooth and the surface clothed with a few hairs. The penis has the form shown in fig. 90 . The ventral plate is divided into two lobes, each of which has one superior and two inferior setae. The glans ends in a sharp point, behind which on the dorsal side is a narrow bifid process. On each side of the glans a pointed lateral process curves outwards.

The free sternites each have a transverse row of short hairs. The respiratory spiracles are large, crescentic, and not hidden by the fourth coxae.

The legs are unarmed. All calcanei are short, straight and conical; that of leg I being about 1/6 the length of the metatarsus (fig. 91). Tarsi I, III and IV each have four segments. Tarsus II has 14 segments on the left and 15 on the right side of the body. Distitarsus I has two segments and distitarsus II has five. Claws of tarsi III and IV three-pronged, the middle prong being larger than the lateral prongs.







Allonuncia grandis gen. et sp. n.

FIG. 86.—Dorsal view of scutum, free tergites ,chelicerae and pedipalpi of male.
FIG. 87.—Lateral view of eyemound.
FIG. 88.—Anterior view of eyemound.
FIG. 89.—Retrolateral view of pedipalpus of male.
FIG. 90.—Ventral view of distal part of penis.
FIG. 91.—Metatarsus and tarsus of leg I of male.

Allotype Female

Measurements in millimeters: Body-length 6·95, length of carapace 2·64, length of scutum 5·56.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	1·67	0 83	2·64	1·11	1·95	2·36	1·53	12·09
Leg 2	2·50	0·83	3·89	1·39	3·06	3·61	3·34	18·62
Leg 3	2·08	0·83	2·64	1·25	2·22	3·06	1·81	13·89
Leg 4	2·50	0·97	3·34	1·53	3·06	4·59	2·22	18·21
Pedi-palp	0·83	1·11	2·92	1·67	2·09	....	2·09	10·71

The colouration of the female resembles that of the male except that the light coloured saddle-shaped area on the dorsal scutum is much smaller and confined to the carapace.

The pedipalpi are armed as in the male but are much smaller. The femur is not so massive and does not bulge backwards over the trochanter.

The tarsal segmentation is 4, 12, 4, 4. Distitarsi I and II have two and four segments respectively.

Localities: The holotype and allotype were collected near Lake St. Clair, Tasmania, 7th February, 1945. The species also occurs at Tarraleah in rain forest at the side of the road to Butler's Gorge. This large harvestman is found under decaying logs in very damp situations amongst ferns and *Notofagus*. At Lake St. Clair it is associated with *Paranuncia gigantea*.

Variations: The collection contains only seven males and five females. The body-length of the males varies from 6·38-8·06 and of the females from 6·09-7·13. The segmentation of the tarsi is shown in Table 8. Both sexes have four segments in tarsi I, III and IV. The males tend to have a greater number of segments in tarsus II, than do the females, but in both sexes the segmentation is variable.

Table 8

Number of specimens	Sex	Number of segments in tarsus I	Number of segments in tarsus II	Number of segments in distitarsus I	Number of segments in distitarsus II
1	♂♂♂♂♂	4	14	2	5
1	♂♂♂♂♂	4	13L 14R	2	4L 5R
1	♂♂♂♂♂	4	14L 15R	2	5
1	♂♂♂♂♂	4	14L 15R	2	5L 6R
1	♂♂♂♂♂	4	15	2	5
1	♂♂♂♂♂	4	15	2	4L 5R
1	♂♂♂♂♂	4	15L 14R	2	6L 5R
1	♂♂♂♂♂	4	11	2	5L 4R
2	♀♀	4	12	2	4
1	♀	4	12L 10R	2	4
1	♀	4	12L 11R	2	4

Genus **NUNCIELLA** Roewer, 1931

Anterior margin of carapace unarmed or with a row of small denticles above. Eyemound arising from the anterior margin. It is low, rounded and unarmed. Scutum without spines and large tubercles. Chelicerae of male with a proximal retrodorsal boss on the first segment. Femur of pedipalpus of male with a large broadly bifid ventral median proximal tooth, which is directed backwards. Calcaneus of each metatarsus much shorter than the astragalus. That of leg I in the male not notched below. The tarsal segmentation: 3, 8-15, 4,4, except in the male of *Nunciella tuberculata*, which according to Forster (1949, p. 73) has four segments in tarsus I. Distitarsi I and II with two and four segments respectively. Claws of tarsi III and IV three-pronged, the middle prong being much stronger than the lateral prongs.

Genotype: *Nunciella aspersa* (Pocock).

Type Locality: Australia.

Seven species belonging to the genus *Nunciella* are recorded from the Australian mainland and one from New Zealand. However, the latter species, *N. granulata* Roewer, is according to Forster (1954, p. 9) 'not found in New Zealand, and the record is probably an error. In the present paper a new species from Tasmania is described. The males but not the females of all species are known. The key at foot of page is therefore based on male characters.

Of the species mentioned in the key *N. woolcocki* is recorded from the Australian Capital Territory, *N. montana* from N.S.W., *N. tuberculata*, *N. cheliplus* and *N. parvula* from Victoria, *N. aspera* and *N. frontalis* from Western Australia and *N. tasmaniensis* from Tasmania. As mentioned above the occurrence of *N. granulata* in New Zealand is doubtful.

NUNCIELLA TASMANIENSIS sp. n.

(Figures 92-97)

Holotype Male

Measurements in millimeters: Body-length 5·43, length of scutum 4·28, length of carapace 2·28.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	1·43	0·51	1·71	0·74	1·14	1·60	1·03	8·16
Leg 2	1·83	0·63	2·17	1·03	1·71	2·17	2·28	11·82
Leg 3	1·43	0·57	1·54	0·86	1·14	1·71	1·31	8·56
Leg 4	1·71	0·69	2·23	1·09	1·66	2·74	1·49	11·61
Pedi-palp	0·86	0·69	2·34	1·26	1·49	....	1·49	8·13

KEY TO MALES OF SPECIES IN GENUS *NUNCIELLA*

1. Eyemound smooth 2
   Eyemound granular 6
2. Femur III with a strong basiventral tubercle .... *N. woolcocki* Forster.
   Femur III without a strong basiventral tubercle 3
3. Femur of pedipalp with one prolateral tooth .... *N. parvula* Roewer.
   Femur of pedipalp with no prolateral teeth 4
4. Femur of pedipalp without a distal ventral tooth .... *N. montana* Forster.
   Femur of pedipalp with a distal ventral tooth 5
5. Femur of pedipalp with four ventral teeth .... *N. tasmaniensis* sp. n.
   Femur of pedipalp with six ventral teeth .... *N. tuberculata* Forster.
6. Basal segment of tarsus I thickened 7
   Basal segment of tarsus I not thickened 8
7. Femur of pedipalp with five small dorsal teeth. .... *N. aspera* (Pocock).
   Femur of pedipalp with two large and two small dorsal teeth .... *N. granulata* Roewer.
8. Femur of pedipalp with four dorsal teeth .... *N. cheliplus* Roewer.
   Femur of pedipalp with eight dorsal teeth .... *N. frontalis* Roewer.

Colour (in alcohol): Scutum reddish-brown with dark markings as shown in fig. 92. Chelicerae and pedipalpi polished reddish-brown with dark reticulations. Legs yellowish-brown with the femora, patellae, tibiae and metatarsi dark-brown in proximal and distal thirds. Ventral surface of body reddish-brown. Coxae II-IV dark at basal ends. Sternites reddish-brown suffused with dark-brown.

Scutum (fig. 92) without spines, smooth and with a matt surface. Scutal groove faintly marked medianly but tergal grooves in the Areas I-V not apparent. Eyemound small, low, smooth and rounded; rising in front from the middle of the anterior margin (fig. 93). A few minute smooth rounded granules are present behind the ocular mound and on the posterior third of the scutum. The granules are difficult to see on specimens immersed in alcohol but are visible on dry specimens. Tergites VI-VIII which are usually free in other species are fused together and to the scutum. Shallow grooves, which do not reach the lateral margins, indicate where fusion has occurred. This unusual condition results in the posterior extension of the scutum so that it covers the whole dorsal surface of the animal. However, the length, 4·28 mm. has been measured from the anterior margin of the carapace to the posterior margin of tergite V. Each of the tergites V-VIII has a transverse row of minute hairs. The anal operculum is free.

Chelicerae strong with a narrow basal segment, 1·94 mm. long, which has on the retrodorsal margin a proximal boss or condyle articulating with the enlarged inner member of the pair of lateral teeth below the anterior margin of the carapace (fig. 92). The second segment is also narrow and measures 2·28 mm. in length. It is unarmed but has a promarginal row of three tubercles on the dorsal surface.

Pedipalpi (fig. 94) large and powerful. Longer than the body. Coxa with a ventral tooth. Trochanter unarmed. Femur armed with a row of three small teeth in the proximal half. Prolateral and retrolateral sides unarmed but the ventral surface has a large proximal bifid tooth and three retroventral teeth. When the femur is depressed the large bifid tooth articulates with a bifid tubercle on the proventral margin of coxa I. Patella with a short blunt prolateral tooth near the apex. Tibia is tuberculate below and with three short teeth on each margin. Tarsus with three teeth on each side. Claw long.

Coxa I with two promarginal teeth, the distal one being wide and bifid at the apex. Coxa II with a blunt tubercle behind the apex. Coxa III with a marginal row of granules in front and behind. Coxa IV with a blunt curved tubercle in front of the apex and a row of granules on the posterior margin. Genital operculum smooth, 0·63 mm. wide and 0·51 mm. from base to apex. Sternum long and narrow. Sternites each with two transverse rows of small hairs but without tubercles. Respiratory spiracles large and not concealed.

Legs smooth except for a few small tubercles below femur I. Calcanei short and conical. Those of the first pair of metatarsi not notched (fig. 95). Tarsal segmentation: 3, 10, 4, 4. Distitarsi I and II with two and four segments respectively. Tarsal claws normal.

Allotype Female

Measurements in millimeters: Body-length 4·74, length of scutum 3·54, length of carapace 1·71.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·97	0·34	1·31	0·63	1·03	1·20	0·91	6·39
Leg 2	1·37	0·40	1·83	0·86	1·43	1·83	1·77	9·49
Leg 3	1·20	0·40	1·31	0·68	0·91	1·43	0·97	6·90
Leg 4	1·48	0·63	1·83	0·91	1·54	2·23	1·26	9·88
Pedipalp	0·68	0·57	1·49	0·86	1·03	....	1·14	5·77

The female exhibits considerable difference from the male. The dark markings on the dorsal surface of the scutum are shown in fig. 96. They are more extensive than in the male. Tergites VI-VIII are free.

Chelicerae are smaller than those of the male. The basal segment has a small promarginal tubercle and two small apical tubercles on the dorsal surface. Second segment has five or six small dorsal tubercles.

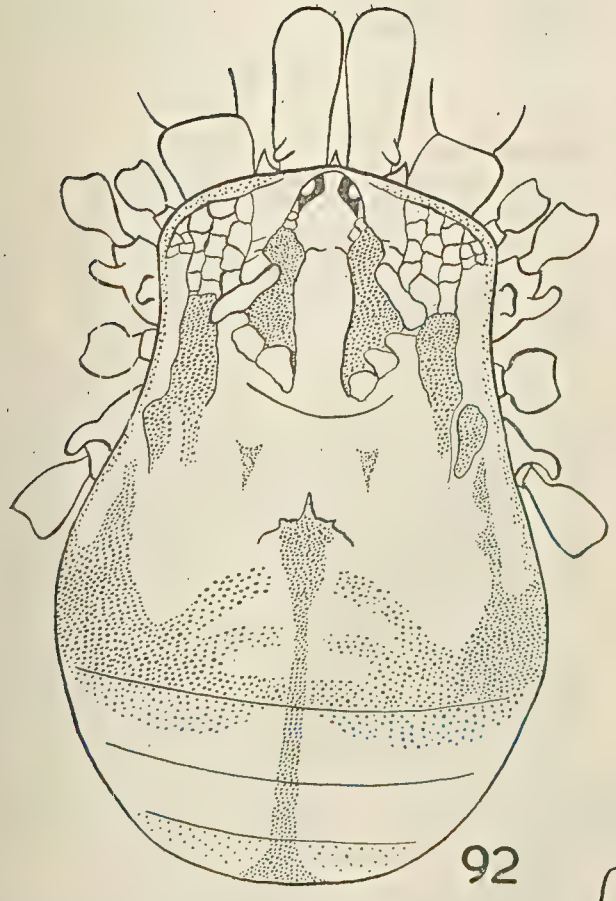
Pedipalpi (fig. 97) strong but smaller than those of the male. Trochanter with a small tubercle below. A median dorsal row of six teeth on the femur. Two teeth are present on the prolateral side, one of which is near the apex. On the ventral surface there is a moderately large and slightly bifid proximal median tooth and a retromarginal row of three teeth, of which the middle tooth is much smaller than the others.

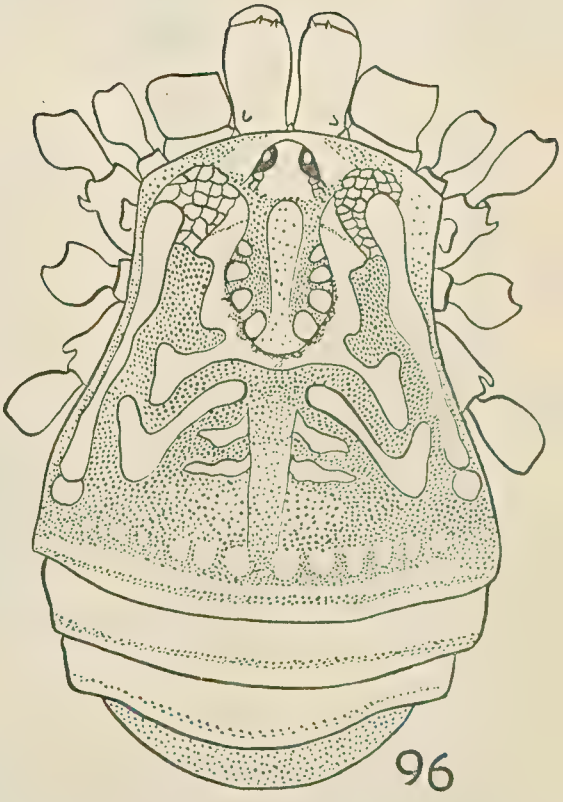
The genital operculum is smooth and measures 0·46 mm. long and 0·63 mm. wide.

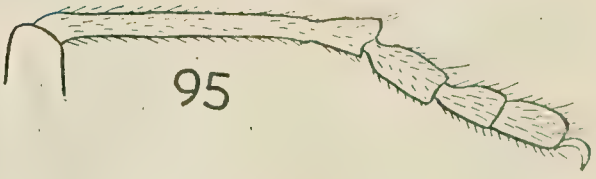
The legs resemble those of the male but are shorter. The number of segments in tarsi I-IV is 3, 9, 4, 4. Distitarsi I and II have two and four segments respectively.

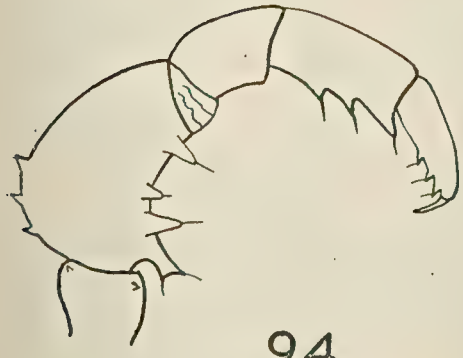
Localities: The type specimens and a large number of others were collected under decaying logs at Weldborough Pass, Tasmania, 25th August, 1953. The species also occurs in the neighbouring districts of Lottah, Gould's Country and St. Columba Falls area.

Variations: The collection contains 30 males and 64 females. The males vary in body length from 3·02-5·80 and the females from 3·48-5·45 mm. The number of segments in tarsi I, III and IV is 3, 4, 4 and appears to be constant in both sexes. Also the number of segments in distitarsus I always appears to be two in both sexes. The segmentation of tarsus II and its distal section (distitarsus II) is variable and much asymmetry is exhibited by both sexes. The segmentation of tarsus II and of distitarsus II is shown in Table 9 for the 94 specimens in the collection.









Nunciella tasmaniensis sp. n.

FIG. 92.—Dorsal view of scutum and fused tergites of male.
FIG. 93.—Lateral view of eyemound.
FIG. 94.—Retrolateral view of pedipalpus of male.
FIG. 95.—Metatarsus and tarsus of leg I of male.
FIG. 96.—Dorsal view of scutum and free tergites of female.
FIG. 97.—Retrolateral view of pedipalpus of female.

Table 9

Number of specimens	Sex	Number of segments in tarsus II	Number of segments in distitarsus II
3	♂	8	4
2	♂	8L 9R	4
5	♂	9	4
2	♂	9L 10R	4
1	♂	9L 10R	4L 5R
1	♂	9L 11R	4L 5R
1	♂	10L 7R	5L 3R
1	♂	10L 8R	4
5	♂	10L 9R	4
3	♂	10	4
2	♂	10L 11R	4L 5R
2	♂	10L 11R	5
1	♂	11L 10R	4
1	♂	11	5
1	♀	8L 7R	4
8	♀	8	4
15	♀	8L 9R	4
1	♀	8L 10R	4L 5R
11	♀	9L 8R	4
1	♀	9L 8R	4L 3R
1	♀	9L 8R	5L 4R
16	♀	9	4
2	♀	9	5L 4R
1	♀	9L 10R	4
3	♀	9L 10R	4L 5R
1	♀	10L 8R	5L 4R
2	♀	10L 9R	4
1	♀	10L 9R	5L 4R

Genus **CINUNA** gen. n.

Eyemound smooth, rounded and unarmed. It is situated in the anterior third of the carapace. Scutum unarmed except for a transverse row of five denticles above the anterior margin on each side. Scutal groove indistinct medianly. Other tergal grooves faintly marked. Each tergal Area and free tergite with a transverse row of granules but without spines and large tubercles. First segment of chelicerae of male with a proximal retrodorsal boss. The median proximal ventral tooth on femur of pedipalp in the male broadly bifid and directed backward. Each calcaneus shorter than the astragalus. Calcaneus of leg I of male not notched below. Tarsi I, III and IV each with four segments in both sexes. Tarsus II variable with 8-14 segments. Distitarsus I has two segments, distitarsus II four to five segments. The claws of tarsi III and IV are three-pronged, the median prong being larger than the lateral prongs.

Genotype: *Cinuna badia* sp. n.

Type Locality: Near Lake St. Clair, Tasmania.

Cinuna is closely related to the genera *Nunciella* Roewer and *Neonuncia* Roewer, the latter as amended by Forster (1954, p. 126). In all three the first segment of the chelicerae has a strong retrodorsal boss in the male. The proximal ventral tooth on the femur of the male pedipalpus is of similar form and the calcaneus of leg I in the males is not notched below. *Cinuna*, however, differs from the other two genera in having four segments in tarsus I.

CINUNA BADIA sp. n.

(Figures 98-104)

Holotype Male

Measurements in millimeters: Body-length 2·57, length of carapace 0·97, length of scutum 2·28.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·57	0·28	0·93	0·46	0·70	0·75	0·75	4·44
Leg 2	0·91	0·34	1·28	0·64	0·99	1·28	1·57	7·01
Leg 3	0·86	0·34	0·99	0·46	0·70	0·93	0·70	4·98
Leg 4	1·03	0·46	1·22	0·64	0·99	1·33	0·93	6·60
Pedipalp	0 34	0·46	1·10	0·64	0·75	....	0·75	4·04

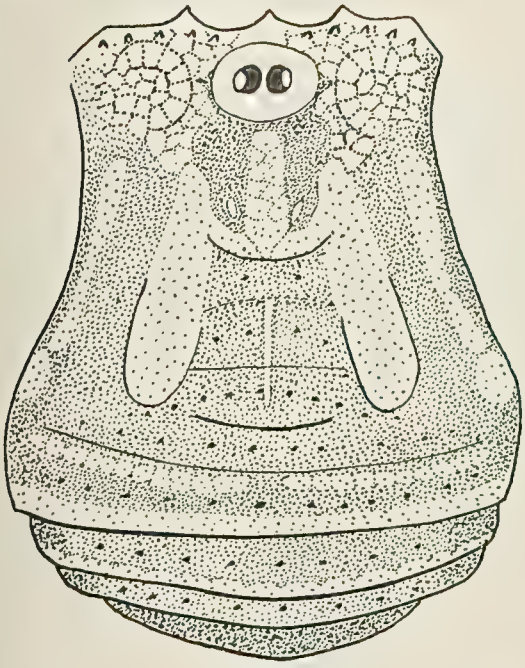
Colour (in alcohol): Dorsal scutum yellowish-brown with dark-brown markings. A pair of elongate light coloured areas situated one on each side of the scutum and connected by a light coloured transverse region immediately behind the carapace. Free tergites brown. Dark reticulations are present on pedipalpi, chelicerae and on each side of the anterior quarter of the scutum. Coxae and genital operculum yellowish. Legs light-brown with dark markings.

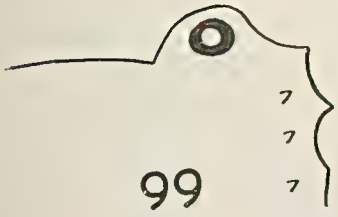
Dorsal scutum (fig. 98) finely shagreened. A row of five small tubercles on each side above the anterior margin. Eyemound smooth, rounded and situated about half its transverse diameter from the front margin (figs. 99 and 100). Transverse grooves distinct in the median scutal region but becoming indistinct laterally. Tergal Areas and each free tergite marked with a transverse row of minute granules. The first three tergal rows having only a small number of granules and not extending onto the sides of the scutum.

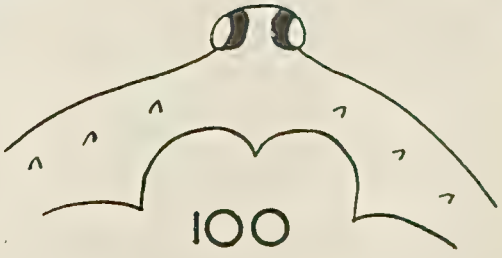
Dorsal surface of first segment of chelicerae with a single tooth at the apex and two on the outer side near the base, the more proximal one serving as a boss or condyle (fig. 101). The dorsal (frontal) surface of the second segment is provided with a few tubercles and an inner row of three small teeth.

Pedipalpi (fig. 102) strong. Trochanter with a transverse row of three small teeth above and a single tooth below. Femur has a dorsal median row of four teeth. The prolateral surface has two tubercles above and a tooth below near the apex. The retrolateral surface has two small tubercles below near the base. The ventral surface has a large median proximal tooth, which is directed backwards. The apex of the tooth is somewhat laterally compressed and obliquely truncated. When the femur is depressed the tooth comes into contact with a broad apical tooth on the anterior margin of coxa I. The proventral margin has a row of three small granules. The retroventral margin is provided with two strong teeth, the first being the larger. Patella has a small conical tooth on the inner side near the apex. The tibia has three teeth on each side and a few granules on the ventral surface. The tarsus is armed with three teeth on each side. The claw is about half the length of the segment.

Coxae granulate. Front margin of coxa I has two teeth, one near the middle and the other at the apex. The apical tooth is wide and bifid at the top, narrow at the base. Coxa II has two coarse tubercles above and several smaller rounded tubercles behind the distal end. Coxa III is provided with a marginal row of granules in front and behind. Coxa IV has a few rounded tubercles in front of the distal end and a marginal row of granules behind. Genital operculum measures 0·41 mm. long and 0·46 mm. wide. It is rounded and smooth in front and is clothed with a few hairs. The respiratory spiracles are crescentic, moderately large and not hidden by the fourth coxae.







Cinvna badia gen. et sp. n.

Fig. 98.—Dorsal view of scutum and free tergites of male.
Fig. 99.—Lateral view of eyemound.
Fig. 100.—Anterior view of eyemound.
Fig. 101.—Dorsal view of chelicerae of male.
Fig. 102.—Retrolateral view of pedipalpus and apical tooth on coxa of leg I of male.
Fig. 103.—Metatarsus and tarsus of leg I of male.
Fig. 104.—Metatarsus and tarsus of leg II of male.

Legs unarmed but the femora and tibiae are slightly tuberculate. Calcaneus of each metatarsus very short, straight and conical (figs. 103 and 104). That of leg I is not notched. Tarsal segmentation is 4, 8, 4, 4. Distitarsi I and II have two and four segments respectively. Claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

Allotype Female

Measurements in millimeters: Body-length 3·31, length of carapace 1·20, length of scutum 2·68.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·57	0·29	1·08	0·51	0·80	0·97	0·86	5·08
Leg 2	1·03	0·40	1·54	0·63	1·14	1·48	1·71	7·93
Leg 3	0·86	0·34	0·97	0·51	0·74	1·08	0·80	5·30
Leg 4	1·14	0·46	1·37	0·68	1·14	1·71	0·91	7·41
Pedipalp	0·40	0·40	1·25	0·74	0·86	....	0·69	4·34

Colouration and general features of the female resemble those of the male, but the dark-brown areas of the dorsal scutum are more extensive. The pedipalpi are less robust and the proximoventral tooth on the femur is smaller and more slender. The tarsal segmentation is 4, 10, 4, 4. Distitarsi I and II have two and four segments respectively.

Localities: The holotype male was collected under a decaying log near Lake St. Clair, Tasmania, 7th February, 1945 and the allotype female, together with two other females, was found under decaying logs at the side of the Lyell Highway, about 23 miles from Queenstown, 23rd May, 1954.

Variations: The collection contains only the single male and three females. The latter vary in body-length from 2·32-3·31 mm. In all the specimens tarsi I, III and IV each have four segments. Tarsus II has eight to ten segments. Distitarsus II has four segments in all specimens except one of the females which is asymmetrical and has three segments on the left and four on the right side of the body.

CINUNA DENTATA sp. n.

(Figures 105-110)

Holotype Male

Measurements in millimeters: Body-length 4·85, length of carapace 1·43, length of scutum 3·43.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·97	0·40	1·74	0·87	1·22	1·68	1·16	8·04
Leg 2	1·43	0·57	2·55	1·10	1·80	2·38	2·49	12·32
Leg 3	1·37	0·51	1·68	0·75	1·28	1·74	1·16	8·49
Leg 4	1·71	0·69	2·03	1·04	1·86	2·61	1·56	11·50
Pedipalp	0·57	0·57	2·51	1·43	2·00	....	1·71	8·79

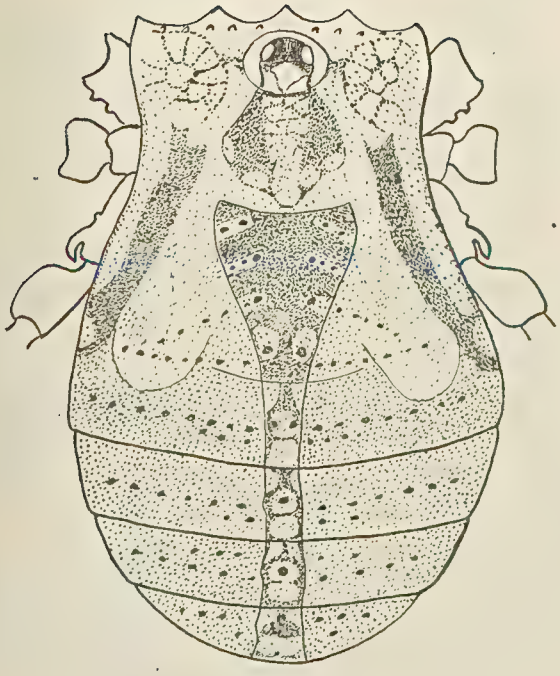
Colour (in alcohol): Dorsal scutum with dark reticulations on each side of the anterior quarter and a light-brown saddle-shaped region behind the carapace. On each side of the saddle-shaped region is a longitudinal dark-brown patch. In a median position an elongate dark-brown club-shaped mark extends from the first scutal groove to the posterior end of the body. The wide anterior end of the mark is divided into four transverse bars corresponding to the first four tergal Areas (fig. 105). The chelicerae, palpi and legs are light-brown with dark reticulations.

The dorsal scutum is provided with five small granules on each side above the anterior margin. Behind the row of granules is a well marked groove. The eyemound is unarmed and rounded. It is situated about half its transverse diameter from the front margin (figs. 106 and 107) and furnished with a few rounded granules. The first scutal groove is deep and well developed medianly, the others are faintly indicated. Each tergal Area and free tergite is marked with a transverse row of granules. Towards the median line the granules tend to form more than one row and are arranged somewhat irregularly. On each tergal Area two of the granules are enlarged to form a median pair of tubercles, and on each free tergite one granule is enlarged to form a single median tubercle.

Chelicerae are large and strong. The first segment is 1·71 mm. long and has on the dorsal side a small inner tooth at the apex, two small tubercles near the middle and a large outer boss or tubercle at the base. The second segment measures 2·06 mm. long and has on the dorsal (frontal) surface an inner row of three teeth and a median row consisting of a small basal tooth and four small tubercles. On the outer side immediately above the junction with the movable finger is a very large curved tooth (fig. 108).

Pedipalpi (fig. 109) large and strong. The trochanter has a small tooth above and a small conical tubercle on the outer side below. The femur has a dorsal median row of four teeth in the proximal two thirds. The teeth curve inwards and the third tooth is the largest. The prolateral surface has two small teeth above and a larger tooth below in the distal third. The retrolateral side has a row of about seven small granules below. On the ventral surface there is a large median proximal tooth, which is laterally compressed and obliquely truncated. It is directed backwards and, when the femur is depressed, comes into contact with a large broad apical tooth on the anterior margin of coxa I. In front of the large proximal tooth and united with it is a large conical tooth. On the proventral margin there is a row of small granules, and on the retrovental margin a row of four teeth, the first being the largest. The patella is somewhat tuberculate on the dorsal surface and has a large prolateral tooth and a smaller retrolateral tooth below the apex. The tibia is tuberculate on both dorsal and ventral surfaces. It is armed with three prolateral and four retrolateral teeth. The tarsus is slightly tuberculate on the ventral surface and has three teeth on each side. The claw is about $\frac{1}{3}$ the length of the segment.

Coxae granulate on the ventral surface. Coxa I has a short stout rounded tooth near the middle of the anterior margin and a large broad bifid tooth at the apex. Coxa II is coarsely tuberculate behind the distal end. Coxa III has a marginal row of granules in front and behind. Coxa IV is furnished with a curved apical tooth and a few tubercles in front of the distal end. A few granules are present on the posterior margin in the distal half. The genital operculum is as long as wide, somewhat triangular, with rounded sides. The surface is clothed with a few hairs.



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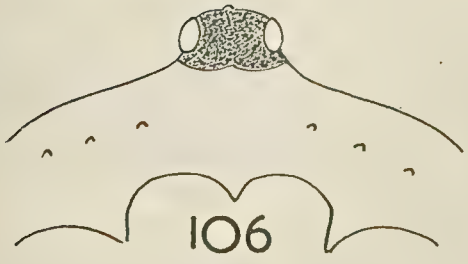

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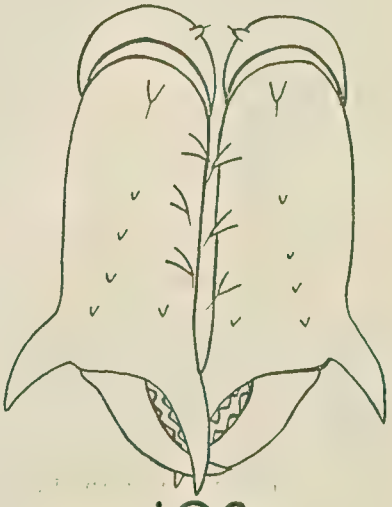


108

Cinuna dentata gen. et sp. n.

FIG. 105.—Dorsal view of scutum and free tergites of male.
FIG. 106.—Anterior view of eyemound.
FIG. 107.—Lateral view of eyemound.
FIG. 108.—Front (dorsal) view of second and third segments of chelicerae of male.
FIG. 109.—Retrolateral view of pedipalpus of male.
FIG. 110.—Metatarsus and tarsus of leg I of male.

The respiratory spiracles are large, crescentic and not hidden by the fourth coxae.

The legs are short and unarmed. The calcaneus of each leg is much shorter than the astragalus and somewhat conical in shape. That of leg I is not notched (fig. 110). Tarsi I, III and IV each have four segments. Tarsus II has 12 segments on the left and 10 on the right side. Distitarsi I and II have two and four segments respectively. Claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

Locality: The holotype and one other male were found by Mr C. Oke on the slopes of Mt Wellington, Tasmania, September, 1949.

Variations: The other male specimen differs from the holotype in having more segments in tarsus II, 14 on the left and 11 on the right. Distitarsus II has five segments on the left and four on the right. In the other tarsi the segmentation of the two specimens is the same.

Genus **NUNCIOIDES** gen. n.

Eyemound low, unarmed and situated behind the anterior margin in the anterior third of the carapace. The anterior margin of the carapace is furnished above with a transverse row of five or six denticles on each side. The scutal groove is distinct medianly, the other tergal grooves absent. Tergal Areas and free tergites with or without a transverse row of granules but devoid of spines and large tubercles. First segment of the chelicerae in males provided with a strongly developed proximal retrodorsal boss. Median proximal tooth below the femur of the pedipalpus in males broadly bifid and directed backwards. Calcaneus of each metatarsus straight and much shorter than astragalus. The calcaneus of leg I in males not notched below. Tarsal segmentation: 5-6, 15-21, 4, 4. Distitarsus I has two segments and distitarsus II six to eight segments. Claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

Genotype: *Nuncioides infrequens* sp. n.

Type Locality: National Park, Tasmania.

In the males possessing a strong retrodorsal proximal boss on the first segment of the chelicerae, a broad bifid median proximal tooth on the ventral surface of the pedipalpus, and a straight non-notched calcaneus on leg I, the genus *Nuncioides* shows a close affinity with the genera *Nuncicella* Roewer, *Neonuncia* Roewer and *Cinuna* gen. n. However, it differs from these genera in the larger number of segments in tarsus I and also in distitarsus II.

In addition to the genotype one other species is assigned to the genus *Nuncioides*. The two may be distinguished as follows:—

Tarsus I with five segments .... *N. infrequens* sp.n.

Tarsus I with six segments .... *N. dysmicus* sp. n.

NUNCIOIDES INFREQUENS sp. n.

(Figures 111-115)

Holotype Male

Measurements in millimeters: Body-length 4·85, length of scutum 4·00, length of carapace 1·83.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	1·03	0·57	2·23	0·91	1·54	2·06	1·49	9·83
Leg 2	1·71	0·69	2·91	1·20	2·34	2·97	3·31	15·13
Leg 3	1·43	0·57	2·06	0·91	1·49	2·34	1·54	10·34
Leg 4	2·11	0·69	2·86	1·14	2·11	3·54	1·83	14·28
Pedipalp	0·86	0·57	2·23	1·26	1·71	....	1·37	8·00

Colour (in alcohol): Scutum reddish-brown with dark reticulations on each side of the carapace. A median pair of elongate dark-brown marks between eyemound and scutal groove. A large dark-brown area is situated on each side of the scutum. Tergal Areas I-III each have a recurved dark band across the median region. Areas IV, V and the free tergites each have a dark-brown transverse band extending from side to side. The chelicerae and pedipalpi reddish-brown with dark reticulations above. Legs dark-brown speckled with reddish-brown. Coxae light-brown with faint dark reticulations. Free sternites dark brown.

Scutum (fig. 111) unarmed and smooth except for a transverse row of small denticles above the anterior margin on each side of the carapace and a row along the lateral ridge at each side of the scutum. Eyemound low and unarmed (fig. 112). It is situated about half its diameter behind the front margin. Scutal groove shallow, other tergal grooves absent. Free tergites smooth.

Chelicerae large and strong. The first segment is elongate and narrow. It measures 1·71 mm. in length and is provided with a small prodorsal tooth at the apex and another small tooth near the middle of the retrodorsal margin. A well developed boss is situated at the proximal end of the retrodorsal margin (fig. 113). The second segment is 2·11 mm. long and furnished with three small tubercles along the prodorsal margin, the middle tubercle being the largest.

Pedipalpi (fig. 114) large and strong. The coxa has two small tubercles below. The trochanter is armed with a small median tubercle above and a small retroventral tubercle below. On the dorsal surface of the femur there is a median row of five teeth and a small tubercle. The retrolateral surface has in the basal half a row of three small denticles close to the retroventral margin. The prolateral surface is armed with a large tooth in the apical half, and behind the tooth are two small tubercles. The ventral surface is provided with a large proximal median tooth, which slopes slightly backwards and is broadly bifid on the posterior surface. The retroventral margin has two large teeth with a small tubercle between them. The proventral margin has two or three minute granules in the basal half. The patella is armed with a short prolateral tooth. The tibia is slightly tuberculate below and has three teeth on each side. The tarsus also is armed with three teeth on each side. The claw is large being nearly half as long as the segment.

The coxae are furnished with numerous small rounded granules on the ventral surface. Coxa I has a large tooth near the middle of the promargin and a broad bifid tooth at the apex. Coxa II is furnished with a small tooth behind the apex and a broad tubercle above. Coxa III has a marginal row of granules in front and behind. Coxa IV is provided with a small tooth in front of the apex and a row of granules along the posterior margin.

The sternum is long and narrow. The genital operculum is small, smooth and rounded in front. It measures 0·51 mm. long and 0·54 mm. wide. The penis has the form shown in fig. 115. The ventral plate is deeply cleft and furnished with three pairs of inferior setae and one pair of superior setae. The distal end of the glans is elongate and laterally compressed. On each side there is a wing-like lateral process.

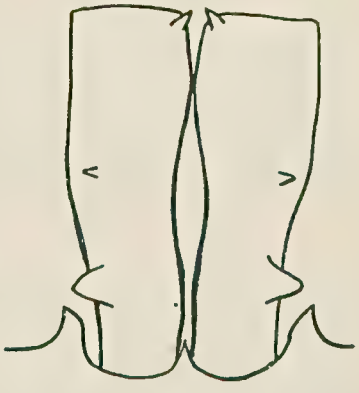
The respiratory spiracles are large and conspicuous. The free sternites smooth.

The legs unarmed but tuberculate on trochanters, femora, patellae and tibiae. The calcaneus of each metatarsus is conical and much shorter than the astragalus. In leg I the calcaneus is about 1/5 the length of the metatarsus and is not notched below. The number of segments in tarsi I-IV is 5, 15, 4, 4. The distitarsi I and II have two and six segments respectively. The claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

Locality: The holotype male is the only specimen of the species in the collection. It was found under a decaying log in rain forest at National Park, Tasmania, 28th February, 1952.

111

115



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Nuncioides infrequens gen. et sp. n.

Fig. 111.—Dorsal view of scutum and free tergites of male.
Fig. 112.—Anterior view of eyemound.
Fig. 113.—Dorsal view of first segment of chelicerae of male.
Fig. 114.—Retrolateral view of pedipalpus of male.
Fig. 115.—Ventral view of distal part of penis.

NUNCIOIDES DYSMICUS sp. n.

(Figures 116-120)

Holotype Male

Measurements in millimeters: Body-length 4·28, length of scutum 3·83, length of carapace 1·66.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	1·31	0·51	2·11	0·86	1·54	2·17	1·43	9·93
Leg 2	1·71	0·63	2·74	1·20	2·40	3·08	3·08	14·84
Leg 3	1·43	0·57	1·94	0·91	1·49	2·28	1·60	10·22
Leg 4	1·71	0·74	2·57	1·14	2·06	3·14	1·94	13·30
Pedipalp	0·80	0·63	2·17	1·14	1·83	....	1·54	8·11

Colour (in alcohol): Scutum dark reddish-brown with dark reticulations each side of the carapace. A pair of longitudinal dark marks is situated between the eyemound and scutal groove. A large dark-brown region on each side of the scutum extends from the carapace almost to the posterior scutal margin. A median dark wedge-shaped area, crossed by a short dark transverse bar on each tergal Area, extends from the scutal groove to the posterior margin of the scutum. The free tergites are dark-brown. Chelicerae and pedipalpi are reddish-brown with dark reticulations. Legs dark-brown speckled with reddish-brown. Coxae reddish-brown. Free sternites dark-brown.

Scutum (fig. 116) unarmed but furnished with a transverse row of six small denticles above the anterior margin on each side. A few denticles are also present on each side in the anterior lateral angles. The eyemound is low, unarmed and situated about its diameter from the front margin (fig. 117). Each tergal Area and free tergite is furnished with a transverse row of small granules but devoid of large tubercles and spines.

Chelicerae large and strong. The first segment (fig. 118) is somewhat narrow and elongate. It measures 1·71 mm. long and has a small prodorsal tooth at the apex. On the retrodorsal margin there is a small denticle near the middle and a large boss at the proximal end. The second segment is 2·00 mm. long and is furnished with a row of four small tubercles along the prodorsal margin.

Pedipalpi (fig. 119) are large and strong. The trochanter has a transverse row of three small denticles above. The dorsal surface of the femur is furnished with a median row of five teeth. The prolateral surface has a conical tooth in the distal half and a row of three small tubercles on the prodorsal margin. The retrolateral surface is furnished with a row of five small granules above the ventral margin. The ventral surface is armed with a large median proximal tooth, which slopes backward and is broadly bifid. The retroventral margin has a row of two large teeth and three small denticles, arranged alternately with the teeth. The proventral margin has a row of five granules. The patella is armed on the prolateral side with a tooth and a small tubercle. The tibia is slightly tuberculate below and has three teeth on each side. The tarsus also has three teeth on each side.

Coxa I (fig. 120) has a large broad bifid tooth at the apex of the promargin and a smaller conical tooth near the middle of the margin. Behind the teeth the ventral surface is furnished with a few small tubercles. Coxa II has several conical tubercles behind the apex and a large broad tubercle above. Coxa III is furnished with a marginal row of granules in front and behind. Coxa IV has several conical tubercles in front of the apex and a row of granules along the posterior margin. The ventral surface of all the coxae granulate.

The sternum is long and narrow. The genital operculum is smooth with a rounded margin. It measures 0·40 mm. in length and width. The respiratory spiracles are large and conspicuous.

The legs are unarmed but the trochanters, femora, patellae and tibiae are slightly tuberculate. The calcaneus of each metatarsus is straight and much shorter than the astragalus, that of leg I being about 1/6 the length of the metatarsus. The number of segments in tarsi I-IV is 6, 21L 20R, 4, 4. Distitarsi I and II have two and eight segments respectively. The claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

Allotype Female

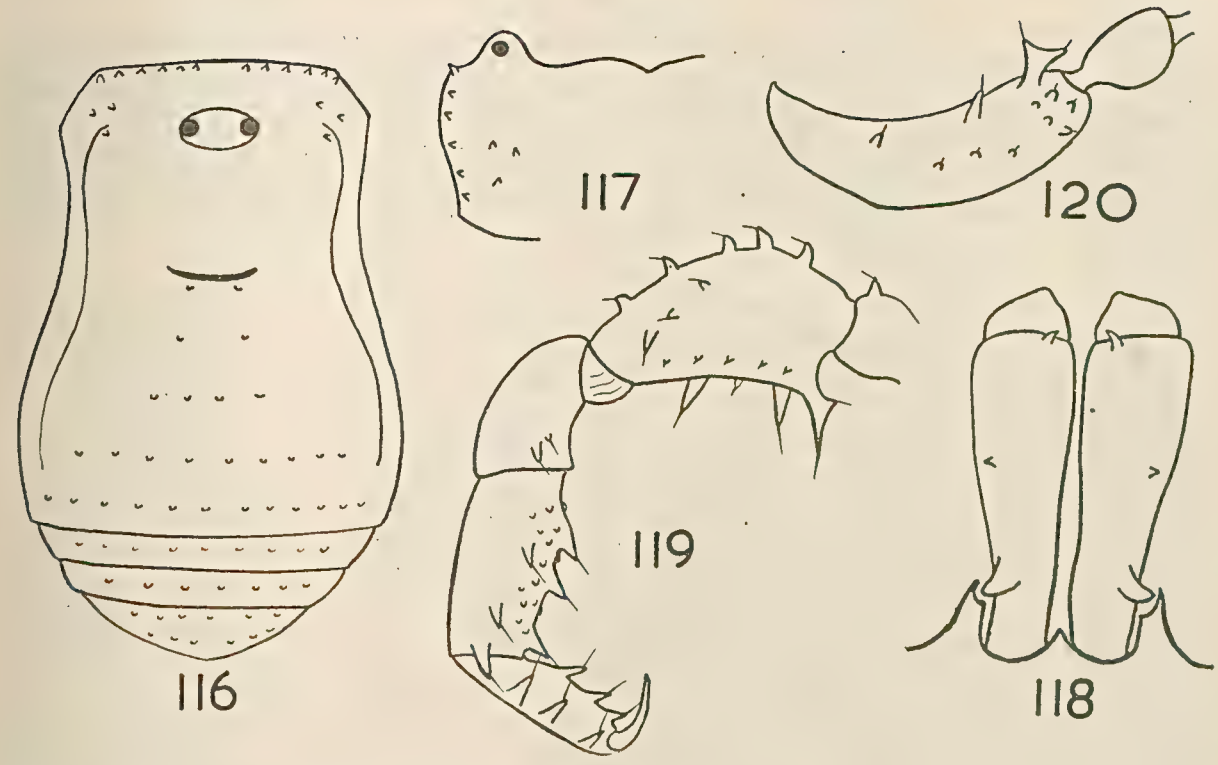
Measurements in millimeters: Body-length 4·85, length of scutum 3·65, length of carapace 1·43.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	1·14	0·46	1·88	0·80	1·49	1·88	1·26	8·91
Leg 2	1·54	0·57	2·86	1·09	2·28	2·86	3·20	14·40
Leg 3	1·37	0·57	2·00	0·80	1·43	2·23	1·31	9·71
Leg 4	1·60	0·69	2·68	1·03	1·94	3·14	1·71	12·79
Pedipalp	0·74	0·57	1·71	1·14	1·20	....	1·14	6·50

The female resembles the male in colour and general appearance but does not have the retrodorsal proximal boss on the first segment of the chelicerae. The pedipalpi are smaller than those of the male and the median proximal tooth below the femur is not as large. The genital operculum is smooth and measures 0·57 mm. wide and 0·51 mm. long. The tarsal segmentation: 6, 18L 19R, 4, 4. Distitarsi I and II have two and seven segments respectively.

Locality: The type specimens and one other male were found under decaying logs on the southern side of the Lyell Highway about 25 miles from Queenstown, Tasmania, 23rd May, 1954.

Variations: The second male specimen has the same number of segments in tarsi I-IV as does the holotype, but in distitarsus II there are nine segments on the left and eight on the right side of the body.



Nuncioides dysmicus gen. et sp. n.

FIG. 116.—Dorsal view of scutum and free tergites of male.
FIG. 117.—Lateral view of eyemound.
FIG. 118.—Dorsal view of first segment of chelicerae of male.
FIG. 119.—Prolateral view of pedipalpus of male.
FIG. 120.—Ventral view of left coxa I.

Genue **PARANUNCIA** Roewer, 1914

A row of short conical spines on each side immediately behind the anterior margin of scutum. Eyemound conical and slightly removed from the margin. Tergal Areas I-III each with a pair of spines. Areas IV and V and the free tergites without spines. Legs unarmed. Calcaneus of each metatarsus shorter than the astragalus. In the male the calcaneus of leg I is notched below. Tarsus I has four segments in the male and three in the female. Tarsus II is variable but usually has 9-13 segments. Tarsi III and IV each have four segments. The claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

Genotype: *Paranuncia gigantea* Roewer.

Type Locality: Tasmania.

PARANUNCIA GIGANTEA Roewer

(Figures 121-125)

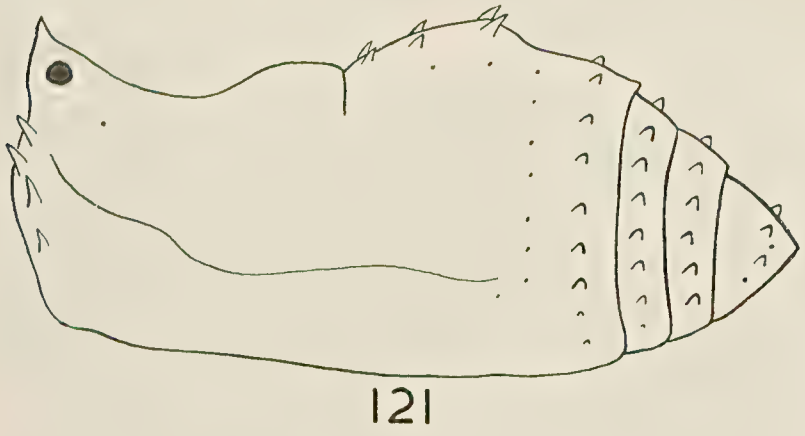
This large harvestman was first described by Roewer (1914, p. 108). A more detailed account of the species is given by Forster (1949, p. 75), who states, however, both in the definition of the genus and in the description of the species, that the calcaneus of leg IV of the male is notched below. This is an error. It is the calcaneus of leg I and not of leg IV that is notched.

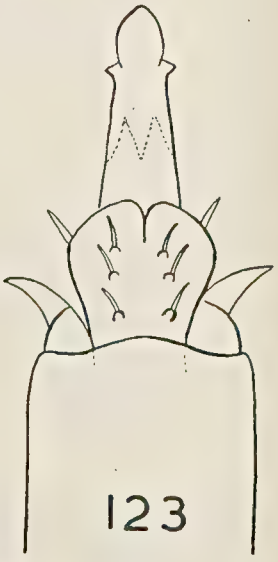
The collection before me contains over a hundred specimens of the harvestman and it is therefore possible to add some further details to existing descriptions.

The form of the penis is shown in figs. 123 and 124. The ventral plate is rounded in front but has a short median cleft. It is furnished with three pairs of inferior and one pair of superior setae. The dorsolateral plates are small. The glans is elongate and slightly curved at the distal end. A long narrow bifid process is closely applied to the dorsal surface of the glans in the proximal three-fifths.

Localities: The collection contains specimens of *Paranuncia gigantea* from Quamby Bluff, Western Creek, Wilmot, Forth Falls, Westmorland Falls, Liffey Falls, Lake St. Clair, Fern Glade at Burnie, Hellyer Gorge, Parrawe and Corinna. It will be noticed that the localities mentioned are all in the north-west quarter of Tasmania. The harvestman occurs in rain-forest areas having such vegetation as *Notofagus*, *Atherosperma* and *Dicksonia* and is usually found under decaying logs. Although the species has been searched for in similar environments in the north-east and south-east of the State, it has not been encountered. No collecting has as yet been carried out in the south-west quarter.

Variations: The collection contains 47 males and 64 females. The males vary in body-length from 5·22-8·70 and females from 6·26-10·01 mm. Tarsus I (fig. 125) has four segments in all the males and three in all the females. The number of segments in tarsus II varies from 9-13 in males and 8-12 in females. One abnormal male has only five segments in the left tarsus II but nine in the right. Tarsi III and IV each have four segments in all specimens. Distitarsi I and II have two and three segments respectively in both sexes. Many specimens are asymmetrical in the number of segments occurring in tarsus II on left and right sides of the body. (See Table 10.) One very asymmetrical female has 11 segments in tarsus II on the left and only four on the right. The right appendage does not appear to have been injured in any way.





Paranuncia gigantea Roewer.

FIG. 121.—Lateral view of scutum and free tergites of male.
FIG. 122.—Retrolateral view of pedipalpus of male.
FIG. 123.—Ventral view of distal part of penis.
FIG. 124.—Lateral view of distal parts of penis.
FIG. 125.—Metatarsus and tarsus of leg I of male.

Table 10

Number of specimens	Sex	Number of segments in tarsus II	
1	♂	5L	9R
4	♂	9	
1	♂	9L	10R
1	♂	10L	9R
8	♂	10	
6	♂	10L	11R
1	♂	10L	12R
1	♂	10L	13R
2	♂	11L	9R
6	♂	11L	10R
7	♂	11	
1	♂	11L	13R
1	♂	12L	7R
6	♂	12L	11R
1	♂	13L	12R
3	♀	8L	9R
12	♀	9	
8	♀	9L	10R
2	♀	9L	11R
11	♀	10L	9R
11	♀	10	
4	♀	10L	11R
1	♀	10L	12R
1	♀	11L	4R
1	♀	11L	9R
3	♀	11L	10R
6	♀	11	
1	♀	12	

Genus **ODONTONUNCIA** gen. n.

Eyemound situated slightly behind the anterior margin. It is low and broad, but armed above with a small recurved spine. The front margin of the carapace is furnished above on each side with a transverse row of four denticles. Tergal grooves faintly marked. Tergal Area III with a median pair of small teeth, other tergal Areas and the free tergites each with a transverse row of granules, but without spines and large tubercles. First segment of the chelicerae in the male without a proximal retrodorsal boss. The pedipalpus of both sexes with a large bifid median tooth below the base of the femur. Sternum long and narrow. Legs unarmed but tuberculate below the femora. Calcaneus of each metatarsus conical and straight, much shorter than the astragalus. Calcaneus of leg I of male not notched below. Tarsus I has four segments in males and 3-4 in females. Tarsus II has 8-13 segments. Tarsi III and IV each have four segments. Distitarsi I and II have two and three segments respectively. Claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

Genotype: *Odontonuncia saltuensis* sp. n.

Type Locality: Goulds Country, Tasmania.

The genus *Odontonuncia* shows some affinity with *Paranuncia* Roewer. However, it differs from the latter genus in the shape of the eyemound, the spination of the tergal Areas and the form of the calcaneus in leg I of the male.

ODONTONUNCIA SALTUENSIS sp. n.

(Figures 126-131)

Holotype Male

Measurements in millimeters: Body-length 7·65, length of scutum 5·82, length of carapace 2·86.

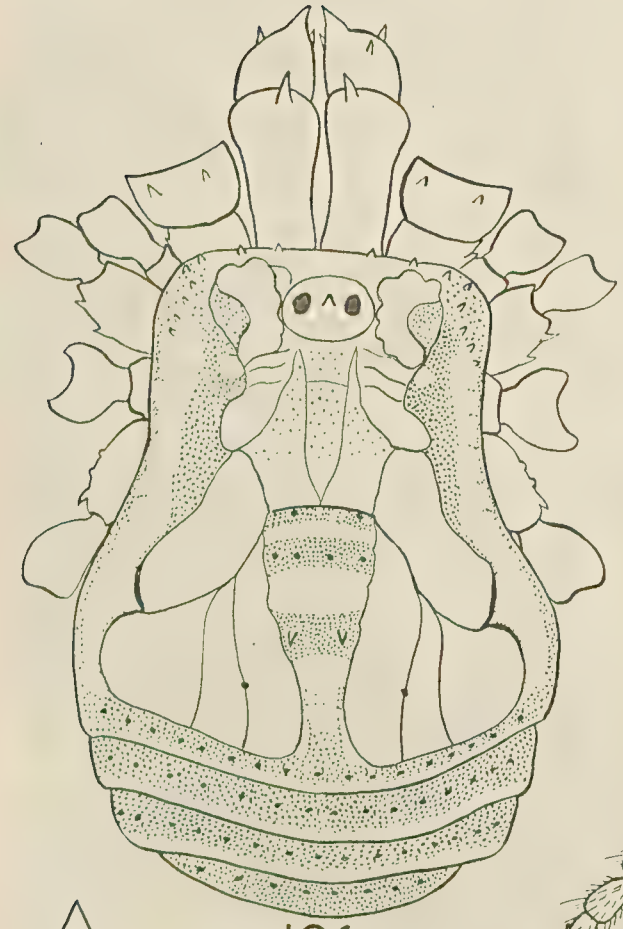
	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	1·77	0·86	3·26	1·43	2·57	3·08	1·66	14·63
Leg 2	2·86	1·03	4·57	1·71	3·88	4·85	3·60	22·50
Leg 3	2·51	1·03	3·14	1·49	2·40	3·71	2·11	16·39
Leg 4	3·03	1·14	4·40	1·71	3·14	5·60	2·46	21·48
Pedipalp	1·31	1·14	3·43	2·46	2·28	....	2·17	12·79

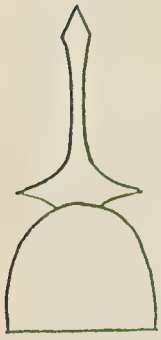
Colour (in alcohol): Scutum dark reddish-brown with a large saddle-shaped region of lighter brown on the posterior half. The median tergal region is crossed by a series of short dark bars, one on each of the Areas I-IV. The free tergites and Area V are dark-brown. Appendages reddish-brown with dark reticulations. Ventral surface of body light reddish-brown.

Carapace (fig. 126) furnished with a transverse row of four denticles above the anterior margin on each side, and an oblique row of four denticles across the antero-lateral angles. The eyemound (figs. 127 and 128) is set back from the front margin by a distance equal to about half its diameter. It is somewhat low and broad and is armed above by a small recurved spine. Tergal Area I is furnished with a median pair of granules. Area II with a transverse row of four granules. Area III with a median pair of small conical teeth and Area IV with a pair of widely spaced granules. Area V and each free tergite has a transverse row of granules extending from side to side. Tergal grooves faintly marked.

Chelicerae strong. The first segment is somewhat elongate and measures 2·11 mm. in length. It has a single median apical tooth on the dorsal side but is without a retrodorsal proximal boss. The second segment measures 3·31 mm. long and has two large teeth on the prodorsal margin and three much smaller teeth in a median dorsal row.

Pedipalpi (fig. 129) very robust and powerful. Trochanter armed with a small tooth below and two denticles above. On the dorsal side of the femur there is a median row of three teeth, the first two of which are large and in the proximal half, the third small and in the distal half. On the prolateral side there is a row of four small teeth along the prodorsal margin and two larger teeth below near the apex. On the retrolateral side there is a row of four granules above the ventral margin in the proximal half. On the ventral side the femur is armed with a very large bifid median proximal tooth, which is set somewhat obliquely. The posterior prong of the tooth has a small accessory spine behind and also another on its mesial surface. The retroventral margin is armed with two large teeth. The proventral margin is without teeth but has a row of small granules. The patella has two large prolateral teeth and a small retrolateral denticle. The tibia is armed with a prolateral row of three teeth, the first two of which are large and about equal in size, the third much smaller. On the retrolateral side there is a row of four teeth, the second and third being larger than





Odontonuncia saltuensis gen. et sp. n.

FIG. 126.—Dorsal view of scutum and free tergites of male.
FIG. 127.—Lateral view of eyemound.
FIG. 128.—Anterior view of eyemound.
FIG. 129.—Retrolateral view of pedipalpus of male.
FIG. 130.—Sternum and genital operculum of male.
FIG. 131.—Metatarsus and tarsus of leg I of male.

the first and fourth. The tarsus has three teeth on each side. The claw is long and well curved.

Coxa I with a promarginal row of three teeth, the apical tooth being bifid, the middle tooth the largest and sloping inwards, the basal tooth the smallest. Coxa II has three small teeth behind the apex. Coxa III is furnished with a marginal row of granules in front and behind. Coxa IV has a single tooth and several small tubercles in front of the apex and a row of four granules on the posterior margin opposite the respiratory spiracle.

Sternum (fig. 130) is long and narrow. The genital operculum measures 0·70 mm. long and 0·81 mm. wide. It has a smooth rounded margin, which is rebordered in front.

The free sternites without tubercles but furnished with a transverse row of hairs. Respiratory spiracles not concealed by fourth coxae.

The legs are unarmed but slightly tuberculate below the femora. The calcaneus of each metatarsus straight, conical and much shorter than the astragalus (fig. 131). All metatarsi have a series of ring-like false segments. The number of segments in Tarsi I-IV is 4, 13L 12R, 4, 4. Distitarsi I and II have two and three segments respectively. Claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

Allotype Female

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	1·83	0·69	2·68	1·14	2·23	2·86	1·60	13·03
Leg 2	2·57	0·74	3·88	1·49	3·14	4·23	3·43	19·48
Leg 3	2·17	0·74	2·86	1·20	2·11	3·37	1·88	14·33
Leg 4	2·68	0·97	3·77	1·31	2·86	5·14	2·00	18·73
Pedipalp	1·14	0·86	2·46	1·71	1·71	....	1·71	9·59

The female resembles the male in colouration except that the light-brown saddle-shaped region is replaced by dark-brown. The part of the scutum between eyemound and the scutal furrow is light-brown.

The pedipalpi are smaller than in the male. The proximal ventral tooth of the femur is not as robust as that of the male but has the same general form. The legs are slightly shorter than those of the male and the tarsal segmentation is 4, 10L 11R, 4, 4.

Locality: The type specimens were collected under fallen decaying logs in *Notofagus* forest at Gould's Country, 26th August, 1953. Other specimens were found in the neighbouring area of Weldborough Pass.

Variations: The collection contains five males and six females. The males vary in body-length from 6·90-8·06 and females from 5·92-6·84 mm. In the males the number of segments in tarsus I is 4 ;in the females it varies from 3-4. Tarsus II has 8-13 segments in the males and 9-11 in the females. Much asymmetry is present in both sexes, 9 of the 11 specimens differing in the number of segments in tarsus II on left and right sides of the body.

Genus **CALLIHAMUS** Roewer, 1931

Eyemound rising directly from the anterior margin of the carapace, conical with rounded apex and armed above in front with a small spine or hook. Front margin of carapace without large spines and not marked off by a transverse groove. Tergal Areas and free tergites unarmed. Legs unarmed or merely provided with blunt tubercles. Calcaneus of each metatarsus shorter than the astragalus. That of leg I in the male not notched below. Tarsal segmentation: 3, 5, 4, 4. Distitarsi I and II have two and three segments respectively. The claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

Genotype: *Callihamus badius* Roewer.

Type Locality: Near Melbourne, Victoria.

Roewer (1931, p. 161) assigns two species to the genus, namely the genotype from Victoria and *Callihamus inermis* Roewer from Tasmania. The description of the Tasmanian species is based on a single male collected near Hobart. *Callihamus inermis* appears to be rare, since among the numerous harvestmen in the present collection there is only one specimen. This happens to be an adult female and is described below.

CALLIHAMUS INERMIS Roewer.

(Figures 132-135)

Allotype Female

Measurements in millimeters: Body-length 3·31, length of scutum 2·74, length of carapace 1·03.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·46	0·23	1·09	0·46	0·86	0·91	0·63	4·64
Leg 2	0·91	0·34	1·49	0·63	1·26	1·43	1·03	7·09
Leg 3	0·80	0·34	1·09	0·51	0·86	1·20	0·69	5·49
Leg 4	1·14	0·40	1·49	0·69	1·26	1·71	0·86	7·55
Pedipalp	0·34	0·23	0·80	0·51	0·57	....	0·57	3·02

Colour (in alcohol): Dorsal surface of body dark-brown with yellowish-brown markings as shown in fig. 132. Chelicerae and pedipalpi yellowish-brown with dark reticulations faintly marked. Legs dark-brown with the distal half of femora, patellae and tibiae light-brown. Coxae light-brown with dark distal ends. Free sternites reddish-brown with broken dark-brown markings medianly and laterally.

Scutum finely shagreened and without tubercles and spines except for a small denticle on the anterior lateral angles. A rounded lobe is situated on the lateral margin of the scutum above the opening of the odoriferous gland on each side. The eyemound is conical and rises directly from the front margin. It is rounded at the apex and armed above in front with a short spine, which is inclined forward (fig. 133). The scutal groove is distinct medianly; the other tergal grooves faintly marked. There is a transverse row of small hairs on each tergal Area and free tergite.

Chelicerae unarmed. The first segment measures 0·46 mm. and the second 0·80 mm. in length.

Pedipalpi (fig. 134) almost unarmed. Trochanter has a small tubercle below. The femur is smooth on dorsal and retrolateral surfaces. The prolateral surface is furnished with a seta in the distal half. The ventral surface has a small median proximal tubercle with a long seta. The retroventral margin is furnished with two minute tubercles. The proventral margin is smooth. The patella is unarmed. The tibia is furnished with a seta on each side in the distal half. The tarsus has three setae on each side.

Coxae are finely shagreened. Coxa I is without sharp spines but has a small slightly bifid blunt tubercle at the apex of the promargin and a few blunt tubercles on the ventral surface. Coxa II with several small tubercles behind the apex and a broad tubercle above. Coxa III with a row of three granules at the distal end of the promargin and about seven along the retromargin. Coxa IV with a few granules in front of the apex and a row of granules along the posterior margin.

Sternum (fig. 135) long and narrow, not widely crescentic posteriorly. Genital operculum large, triangular and smooth. It measures 0·51 mm. long and 0·57 mm. wide. The respiratory spiracles are conspicuous and well removed from the posterior margin of the fourth coxae.

The legs are unarmed but the femora slightly tuberculate below. Calcanei small and knob-like, showing little differentiation. The number of segments in tarsi I-IV is 3, 5, 4, 4. Distitarsi I and II have two and three segments respectively. The claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

Locality: The single specimen was found at Surprise Valley, Lyell Highway, Tasmania, 23rd May, 1954.

The female agrees very closely with Roewer's description of the male, except that it has a larger spine on the eyemound. From the figure that Roewer gives, it appears that the pedipalpi of the male are more robust than those of the female.

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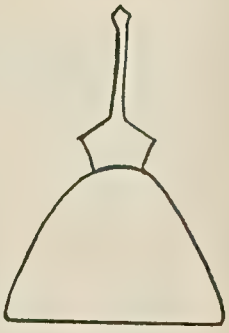


135

.... *Callihamus inermis* Roewer.

Fig. 132.—Dorsal view of scutum and free tergites of female.
Fig. 133.—Lateral view of eyemound.
Fig. 134.—Retrolateral view of pedipalpus of female.
Fig. 135.—Sternum and genital operculum of female.

Genus CALLIUNCUS Roewer, 1931

Eyemound rising directly from the unarmed anterior margin, conical, rounded at the apex and armed above in front with a small spine. Scutum and free tergites without spines and tubercles. Tergal Areas not defined by grooves. Proximal ventral tooth on femor of pedipalpus in the male bifid. Legs unarmed but a few tubercles may be present on the femora. Calcaneus of each metatarsus straight, conical and much shorter than astragalus. Tarsal segmentation: 3, 6-9, 4, 4. Distitarsi I and II with two and three segments respectively. Claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

Genotype: *Calliuncus ferrugineus* Roewer.

Type Locality: Perth, Western Australia.

Two species belonging to the genus *Calliuncus* have been previously described, namely, the genotype from Western Australia and *Calliuncus ephippiatus* Roewer from Victoria. Two new species from Tasmania are described in the present paper. The four may be distinguished by the following key.

KEY TO SPECIES IN THE GENUS *CALLIUNCUS*

1. Patella of pedipalp with a prolateral spine ..... *C. ephippiatus* Roewer.
   Patella of pedipalp without a prolateral spine 2
2. Femur II with two distal retroventral teeth ..... *C. glaber* sp. n.
   Femur II without teeth 3
3. Tibia of pedipalp with four prolateral teeth ..... *C. ferrugineus* Roewer.
   Tibia of pedipalp with two prolateral teeth ..... *C. odoratus* sp. n.

CALLIUNCUS ODORATUS sp. n.

(Figures 136-138)

Holotype Male

Measurements in millimeters: Body-length 3·36, length of scutum 2·63, length of carapace 1·31.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·86	0·34	1·14	0·63	0·86	1·14	0·74	5·71
Leg 2	1·03	0·40	1·66	0·74	1·26	1·54	1·49	8·12
Leg 3	0·91	0·34	1·14	0·51	0·80	1·03	0·91	5·64
Leg 4	1·08	0·51	1·54	0·86	1·26	1·71	1·08	8·04
Pedipalp	0·46	0·34	1·14	0·74	0·80	....	0·86	4·34

Colour (in alcohol): Carapace yellowish-brown with dark-brown reticulations. Behind the carapace is a yellow saddle-shaped area the sides of which extend posteriorly to Area IV. Between and behind the posterior lobes of the saddle-shaped region the scutum is dark-brown marked with a pair of yellowish spots or transverse bars on Areas II-IV and a transverse row of yellowish spots on Area V. On either side of the saddle-shaped region is a large dark-brown patch, below which is a broad yellowish stripe, continuous posteriorly with a row of three or four large yellowish spots in the posterior lateral corners of the scutum. Chelicerae yellowish with dark reticulations. Pedipalpi yellowish with dark reticulations on the femora and tibiae. Coxae yellowish-brown with darker markings. Sternites and tergites dark-brown with yellowish posterior margins. Legs dark-brown with yellow trochanters and yellow spots on femora, patellae and tibiae.

Scutum finely granular; without spines and tubercles. Eyemound low, broadly conical, rising slightly behind the front margin, vertical anteriorly and surmounted in front by a small spine or hook (fig. 136). Scutal groove distinct medianly. Tergal grooves indistinct except that between Areas IV and V. Free tergites without spines and tubercles.

Chelicerae with a median dorsal apical spine and a small retrolateral basal tubercle on the first segment. Three promarginal tubercles on the dorsal side of the second segment, the middle one being the largest. First segment measures 0·74 mm. long and the second 1·14 mm.

Pedipalpi (fig. 137) longer than body. Trochanter with a small tubercle above and below. Femur with a row of three dorsal teeth in the proximal half, a single small prolateral tooth in the distal half, no retrolateral teeth, and a row of three ventral teeth. The proximal tooth in the ventral row is directed backwards and has a broad obliquely truncated apex. Patella with a small ventral tubercle but no spines on either side. Tibia somewhat swollen in the proximal half and has three teeth on the retrolateral side and a small tubercle together with two teeth on the prolateral side. The tarsus is somewhat slender and has three teeth on each side.

Coxa I with two promarginal tubercles of moderate size, one at the apex, the other near the middle. Coxa II with a few small tubercles behind the apex. Coxa III with a marginal row of granules in front and behind in the distal half. Coxa IV with a small tooth in front of and behind the apex, also a few small tubercles in front of the apex and a marginal row of granules behind the coxa. Genital operculum smooth, 0·46 mm. wide and 0·40 mm. long. The penis in the partly extended condition has the form shown in fig. 138. The basal plate is wide and has a short cleft in the middle of the free margin. It is provided with three pairs of inferior and one pair of superior setae. The lateral processes are curved and have a few small denticles at the apex. The distal part of the glans is laterally compressed and ends in a sharp point. It is partly covered by a wide hood which is bifid distally. The sternites are smooth. The respiratory spiracles are small but not concealed. They are situated close behind coxae IV.

Legs are without spines but the femora have a few small tubercles. Calcanei much shorter than the astragali. Tarsal segmentation: 3, 6, 4, 4. Distitarsi I and II with two and three segments respectively.

Allotype Female

Measurements in millimeters: Body-length 3·71, length of scutum 2·74, length of carapace 1·31.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·68	0·29	1·14	0·57	0·86	0·97	0·74	5·25
Leg 2	0·97	0·34	1·54	0·74	1·14	1·37	1·43	7·53
Leg 3	0·91	0·40	0·97	0·57	0·80	0·97	0·80	5·42
Leg 4	1·03	0·46	1·43	0·74	1·20	1·60	0·97	7·43
Pedipalp	0·45	0·34	0·97	0·63	0·74	....	0·80	3·93

The female resembles the male but the pedipalpi are somewhat smaller and the proximal ventral tooth on the femur is sharper. The genital operculum is 0·51 mm. wide and 0·40 mm. long. The tarsal segmentation is the same as that of the male.

Localities: The type specimens were collected at Fern Tree, Mount Wellington, Tasmania, 27th April, 1950. The species is also found in the Arve Forest at Geeveston, and at National Park, Fern Glade at Burnie, and Hellyer Gorge. Specimens have been collected from leaf-mould, from moss, amongst fallen leaves, under stones and under decaying logs.

Variations: The collection contains 20 males and 16 females. The males vary in body-length from 2·38-3·65 and the females from 2·84-3·77 mm. They all have the same tarsal formula: 3, 6, 4, 4, and exhibit no variation or asymmetry in the tarsal segmentation. In colouration and markings, however, the males show much variation. In some the saddle-shaped area on the scutum extends to the posterior margin of the scutum and there is a dark-brown club-shaped median mark, which has a broad concave anterior end immediately behind the scutal groove. Towards the posterior the mark gradually narrows to a median band, which is continued onto the free tergites.

Calliuncus odoratus sp. n.

Fig. 136.—Lateral view of scutum and free tergites of male.
Fig. 137.—Retrolateral view of pedipalpus of male.
Fig. 138.—Lateral view of distal part of penis.

CALLIUNCUS GLABER sp. n.

(Figures 139-144)

Holotype Male

Measurements in millimeters: Body-length 4·80, length of scutum 3·71, length of carapace 1·88.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	1·03	0·46	1·77	0·86	1·31	1·65	1·14	8·22
Leg 2	1·49	0·57	2·51	1·08	1·88	2·40	2·28	12·21
Leg 3	1·31	0·57	1·54	0·74	1·20	1·66	1·43	8·45
Leg 4	1·71	0·68	2·11	1·03	1·71	2·51	1·65	11·40
Pedipalp	0·68	0·51	1·94	1·14	1·54	....	1·26	7·07

Colour (in alcohol): Scutum yellow with brown markings as indicated on fig. 139. Carapace with dark reticulations on each side and behind the eye-mound. Free tergites yellowish-brown with dark median and lateral patches. Chelicerae and pedipalpi yellowish with dark reticulations. Legs mainly dark-brown speckled with yellow. Coxae yellow with dark-brown reticulations. A median yellowish band extends from mouth to anus. On each side of the median yellow band the sternites are dark-brown and intersected by another longitudinal yellow band.

Scutum finely shagreened but without granules, tubercles or spines. The scutal groove is present medianly and the fifth tergal groove faintly indicated. The other grooves are absent. The eye-mound is small, conical and rising directly from the front margin. Anteriorly above it is furnished with a small pointed spine (fig. 139). Free tergites shagreened but without granules, tubercles or spines.

Chelicerae moderately strong. First segment is 1·31 mm. long and armed at the apex with a small prodorsal spine. A small proximal boss is present on the retrodorsal margin. The second segment is 1·66 mm. long and armed with a sharp tooth near the middle of the prodorsal margin.

Pedipalpi (fig. 140) strong. Trochanter has a small tubercle above and below near the retrolateral side. The femur is armed with a median dorsal row of three small teeth in the proximal half. The prolateral surface has two small blunt tubercles below in the distal half and a third one above the middle. The retrolateral surface is smooth. The ventral surface is armed with a large median proximal tooth, which is broadly bifid and directed backwards. The retroventral margin has a row of three teeth, of which the second is much smaller than the other two. The proventral margin is furnished with a row of granules. The patella has a small granule on each side. The tibia is slightly granulate below. On the prolateral side there are two teeth in the distal half, and on the retrolateral side a row of three small tubrecles. The tarsus is furnished with three small teeth on each side. The claw is about ⅓ the length of the segment.

Coxa I has a small bifid tooth at the apex of the promargin and another short blunt tooth near the middle of the ventral surface. Coxa II has a small blunt tooth behind the apex and a few granules on the ventral and posterier surfaces in the distal third. Coxa III is furnished with a marginal row of granules in front and behind. Coxa IV is armed with a blunt tooth in front of and another behind the apex. The posterior margin is furnished with a row of granules. The ventral surface of each coxa is more or less granular and shagreened.

The sternum is narrow and elongate. The genital operculum has a rounded and smooth margin and measures 0·51 mm. long by 0·57 mm. wide. The form of the penis is shown in fig. 141. The ventral plate is deeply cleft and furnished with three pairs of inferior and one pair of superior setae. On each side of the base of the ventral plate is a leaf-shaped rugose lateral process. The glans ends in a hook-shaped structure, which is bent dorsally and protected by a laterally compressed hood or sheath. Above the glans is a narrow bifid dorsal process and on each side a somewhat rough bilobed apophysis.

Each free sternite is smooth and provided with a double row of short hairs. The respiratory spiracles are moderately large and not concealed by the fourth coxae.

The legs are short and stout. Trochanters and femora are somewhat granulate. Femur II (fig. 142) is furnished with two blunt retroventral teeth near the apex. Femur III (fig. 143) has a retroventral row of tubercles, the distal tubercle being tooth-like. Femur IV has a proventral row of tubercles, the distal one also being tooth-like. All calcanei are straight, conical and much shorter than the astragali (fig. 144). Tarsal segmentation: 3, 8, 4, 4. Distitarsi I and II have two and three segments respectively. The claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

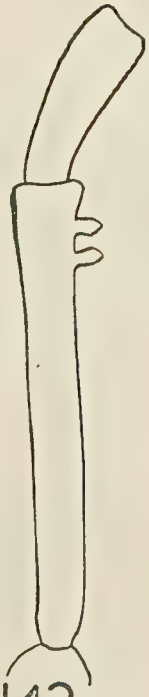
Allotype Female

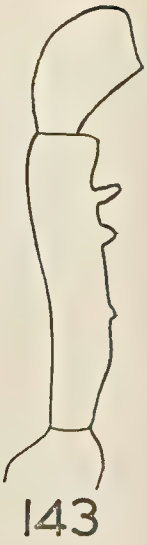
Measurements in millimeters: Body-length 3·43, length of scutum 3·37, length of carapace 1·71.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·86	0·40	1·43	0·74	1·08	1·43	1·03	6·97
Leg 2	1·31	0·46	2·00	0·86	1·54	1·83	1·88	9·88
Leg 3	1·14	0·46	1·25	0·68	0·97	1·25	1·14	6·89
Leg 4	1·43	0·57	1·77	0·91	1·48	2·11	1·31	9·58
Pedipalp	0·85	0·45	1·31	0·86	1·03	....	1·14	5·64

The female resembles the male in general features but the colouration is somewhat darker. The dorsal scutum has a median dark-brown band which extends backwards from the scutal groove and is continued over the free tergites to the posterior end of the body. On tergal Areas I-III the median band is crossed by a dark-brown chevron. The pedipalpi are not much smaller than those of the male. The proximal median ventral tooth on the femur resembles that of the male but is somewhat smaller. There are only two teeth on the retroventral margin and these are more widely spaced than in the male. The female lacks the prominent distal retroventral teeth, which are present on femora II and III of the male and also the proventral teeth on femur IV.

Localities: The type specimens were collected at National Park, Tasmania, 29th August, 1951. The species also occurs at Liffey Falls, Tarraleah and Lake St. Clair. It is found under decaying logs. Adult specimens may be collected during both winter and summer.





Calliuncus glaber sp. n.

FIG. 139.—Lateral view of scutum and free tergites of male.
FIG. 140.—Retrolateral view of pedipalpus of male.
FIG. 141.—Ventrolateral view of distal part of penis.
FIG. 142.—Femur and patella of leg II of male.
FIG. 143.—Femur and patella of leg III of male.
FIG. 144.—Metatarsus and tarsus of leg I of male.

Variations: The collection contains 43 males and 33 females. The males vary in body-length from 3·13-4·64 and the females from 3·48-5·05 mm. Tarsi I, III and IV have 3, 4, 4 segments respectively in all specimens. The variations in the number of segments in tarsus II is shown in Table 11.

Table 11

Number of specimens	Sex	Number of segments in tarsus II
12	♂	7
5	♂	7L 8R
10	♂	8L 7R
12	♂	8
2	♂	8L 9R
2	♂	9L 8R
2	♀	7L 6R
20	♀	7
5	♀	7L 8R
1	♀	8
5	♀	8L 7R

Genus **NUCINA** gen. n.

Eyemound conical, rising from near the front margin and armed above with a short spine or horn. Anterior margin of carapace with a transverse row of four denticles above on each side. Tergal grooves indistinct. A median pair of short spines is present on tergal Areas III and IV. A transverse row of granules or small tubercles on Area V and each free tergite. Chelicerae of male without a proximal retrodorsal boss on the first segment. Median proximal tooth below femur of the pedipalpus in the male not broadly bifid. The calcaneus of each metatarsus much shorter than astragalus. Calcaneus of leg I of male not notched below. Tarsus I with four segments in the male and three in the female. Tarsus II with 8-15 segments in the male and 8-13 in the female. Tarsi III and IV each with four segments in both sexes. Distitarsi I and II with two and three segments respectively. Claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

Genotype: *Nucina silvestris* sp. n.

Type Locality: Tarraleah, Tasmania.

The genus *Nucina* is near *Monacanthobunus* Roewer but differs in the calcaneus of leg I of the male being straight and not notched below. In addition to the genotype one other species, *Nucina dispar* sp. n. is placed in the genus. The two species may be distinguished as follows:—

Tergal Area II with a median pair of spines *N. silvestris* sp. n.

Tergal Area II without spines *N. dispar* sp. n.

NUCINA SILVESTRIS sp. n.

(Figures 145-148)

Holotype Male

Measurements in millimeters: Body-length 3·65, length of scutum 2·97, length of carapace 1·48.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·85	0·34	1·43	0·68	1·14	1·54	1·09	7·07
Leg 2	1·14	0·46	2·06	0·86	1·71	2·06	2·51	10·80
Leg 3	1·03	0·40	1·31	0·74	1·14	1·48	1·14	7·24
Leg 4	1·20	0·51	1·94	0·86	1·54	2·40	1·37	9·82
Pedipalp	0·57	0·40	1·66	0·91	1·54	....	0·97	6·05

Colour (in alcohol): Dorsal scutum yellowish-brown with dark-brown markings as shown in fig. 145. A large light coloured saddle-shaped region covers the posterier two thirds of the scutum. Between the two lobes of the saddle-shaped region is a median wedge-shaped mark composed of four short dark bars, one on each of the tergal Areas I-IV. The bars decrease in width posteriorly. Free tergites each with a transverse row of yellowish spots. Chelicerae yellow with dark reticulations. Pedipalpi yellow with dark reticulations on femora and tibiae, the patellae and tarsi being mainly yellow. Coxae yellowish with dark-brown markings especially on the distal third. Free sternites yellow with dark-brown laterally and a median dark-brown stripe extending posteriorly to the anus. Legs dark-brown speckled with yellow on femora, patellae and tibiae.

Dorsal scutum very finely shagreened. A row of four small granules on each side above anterior margin. The third granule from the eyemound is enlarged to form a small denticle. Scutal groove and tergal grooves faintly marked medianly. Each tergal Area is provided with a transverse row of granules. The rows of Areas I-IV are short and a pair of granules on Areas II-IV and within the median wedge-shaped mark are replaced by a pair of small spines. Area V and each free tergite has a transverse row of granules. The eyemound is conical and surmounted by a short horn or spine (fig. 145). It is set back from the front margin by a distance equal to about half its basal diameter.

Chelicerae moderately strong. The first segment measures 0·74 mm. in length and has a very small tubercle on the dorsal side at the apex. The second segment measures 1·20 mm. long. It is provided with a blunt tubercle and a sharp spine on the inner side of the frontal surface and in the distal half.

Pedipalp (fig. 146) large and strong. Trochanter with a small tooth above and a larger one below. Femur with a median dorsal row of three teeth in the proximal half, the second tooth being the largest. The prolateral surface has a row of three rounded tubercles above and a single small tubercle below near the apex. The ventral side has a large proximal tooth, which is provided with a blunt accessory tooth on its inner surface. The proventral margin is furnished with a row of about four small rounded tubercles, and the retroventral margin with three teeth, the first being the largest. Patella smooth and unarmed. Tibia almost as long as the femur, provided with two large rounded tubercles on the distal half of the prolateral side and three smaller tubercles on the retrolateral side. The ventral surface is slightly granular. The tarsus has three short stout teeth on each side. The claw is nearly half the length of the tarsus.

Coxa I has three small blunt teeth on the anterior margin, the two near the apex being close together. A few small tubercles are present on the ventral surface. Coxa II has an apical tooth and several small tubercles behind the distal half. Coxa III is furnished with a marginal row of granules in front and behind. Coxa IV has two small blunt teeth in front of the distal half, a blunt tubercle behind at the apex and a few marginal granules in front of the respiratory spiracles.

Sternum is elongate and narrow. Genital operculum is somewhat triangular with smooth rounded sides. The penis has the form shown in fig. 147. The ventral plate is large, oval and concave. Its margin is strongly chitinized. Unlike the ventral plate of most other species, it appears to be closely fused with the glans and not capable of separate movement. It is provided with three pairs of small inferior setae. The glans terminates in a laterally expanded end.

Each free sternite is provided with a double row of short hairs. The respiratory spiracles are small but not concealed.

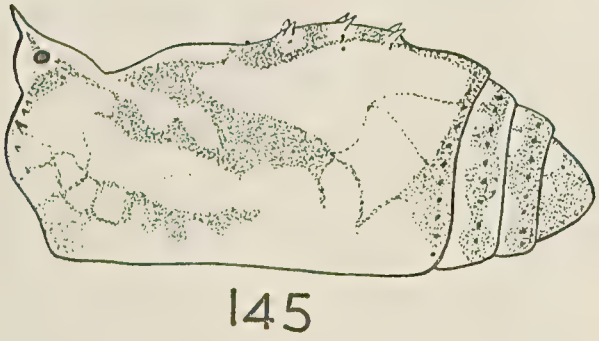
The legs are unarmed but the trochanters and femora are slightly tuberculate. The calcanei are conical and much shorter than the astragali. The calcaneus of leg I is not notched (fig. 148). All metatarsi exhibit false joints. The tarsal segmentation is 4, 10L 11R, 4, 4. Distitarsi I and II have two and three segments respectively. The claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

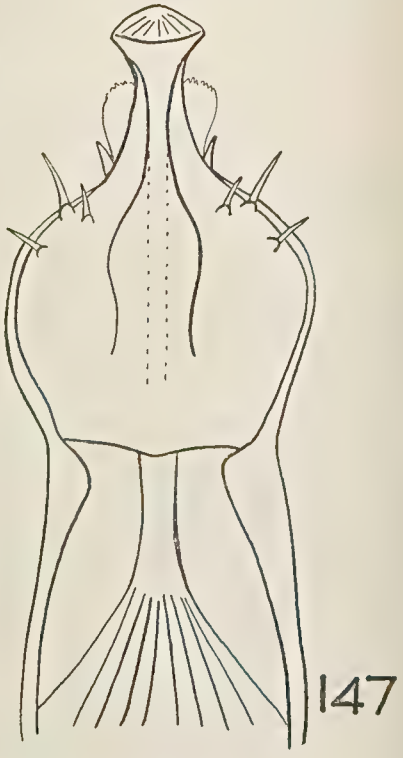
Allotype Female

Measurements in millimeters: Body-length 4·00, length of carapace 1·31, length of scutum 2·63.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·80	0·34	1·25	0·57	0·97	1·37	0·91	6·21
Leg 2	1·08	0·40	1·71	0·80	1·43	1·77	1·94	9·13
Leg 3	0·97	0·34	1·14	0·63	0·97	1·37	1·02	6·44
Leg 4	1·19	0·51	1·83	0·80	1·43	2·11	1·20	9·07
Pedipalp	0·40	0·29	1·14	0·69	0·86	....	0·86	4·24

The female resembles the male. However, the saddle-shaped region on the dorsal scutum is much smaller and does not extend posteriorly beyond tergal Area III.





Nucina silvestris gen. et sp. n.

Fig. 145.—Lateral view of scutum and free tergites of male.
Fig. 146.—Retrolateral view of pedipalpus of male.
Fig. 147.—Ventral view of distal part of penis.
Fig. 148.—Metatarsus and tarsus of leg I of male.

The pedipalpi are smaller and the femur has only two small teeth on the dorsal surface. The prolateral side has one tooth above the middle and one below near the apex. The proximal tooth on the ventral surface has no accessory tooth on its inner surface and the retroventral margin is provided with a row of four teeth. The patella has a small prolateral tubercle. The tibia is much shorter than in the male and about as long as the tarsus. It is armed with three sharp teeth on each side. The distal tooth in both rows being very small. The tarsus has three sharp teeth on each side.

The female also differs from the male in having three segments in tarsus I, the tarsal formula being 3, 10, 4, 4. The distitarsi are as in the male.

Localities: The holotype and allotype were found under decaying logs at Tarraleah, Tasmania, 27th May, 1954. The species is very common at many places in the north-east quarter of the State and the collection contains specimens from Balfour, Hellyer Gorge, Smithton, Table Cape, Burnie, Wilmot, Forth Falls, Mole Creek, Butler's Gorge and Lake St. Clair.

Variations: Seventy-three males and 51 females have been examined. The body-length of the males varies from 2·61-3·77 mm. and of the females from 2·32-4·00 mm. All the males have four segments in tarsus I and all the females have three segments. The number of segments in tarsus II varies from 8-15 in males and 8-13 in females. The segmentation of tarsi I and II in the specimens examined is shown in Table 12. No variations were observed in the segmentation of distitarsi I and II, which have two and three segments respectively in all specimens.

Table 12

Number of specimens	Sex	Number of segments in tarsus I	Number of segments in tarsus II
2	♂	4	8L 10R
1	♂	4	9L 8R
3	♂	4	9
4	♂	4	9L 10R
1	♂	4	9L 11R
3	♂	4	10L 9R
11	♂	4	10
9	♂	4	10L 11R
2	♂	4	11L 9R
11	♂	4	11L 10R
11	♂	4	11
4	♂	4	11L 12R
1	♂	4	12L 10R
2	♂	4	12L 11R
2	♂	4	12L 13R
1	♂	4	13L 12R
2	♂	4	13
1	♂	4	14L 13R
1	♂	4	14
1	♂	4	15L 14R
3	♀	3	8L 9R
2	♀	3	8L 10R
1	♀	3	8L 11R
4	♀	3	9L 8R
13	♀	3	9
5	♀	3	9L 10R
2	♀	3	10L 8R
10	♀	3	10L 9R
2	♀	3	10
1	♀	3	10L 11R
1	♀	3	11R 9R
3	♀	3	11L 10R
1	♀	3	11
1	♀	3	11L 12R
1	♀	3	11L 13R
1	♀	3	12L 13R

NUCINA DISPAR sp. n.

(Figures 149-152)

Holotype Female

Measurements in millimeters: Body-length 2·97, length of scutum 2·74, length of carapace 1·37.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·86	0·34	1·49	0·69	1·20	1·54	1·09	7·21
Leg 2	1·31	0·46	2·11	0·91	1·77	2·06	2·40	11·02
Leg 3	1·20	0·40	1·37	0·69	1·26	1·71	1·20	7·83
Leg 4	1·43	0·51	2·05	0·86	1·71	2·46	1·49	10·51
Pedipalp	0·46	0·46	1·43	0·80	1·14	....	1·03	5·32

Colour (in alcohol): The specimen appears to have recently undergone ecdysis and is therefore probably much lighter in colour than is usual in the adult. The scutum is pale-cream with a dark greyish-brown margin and a large brownish region on each side of the posterior three quarters. The carapace is dark round the base of the eyemound and has a pair of dark patches between the eyemound and scutal groove. Tergal Areas I-III each have a short median transverse pale-yellow bar. Area IV has a median pair of yellow spots, each round the base of a spine. The dark-brown lateral regions are united across the dorsum by dark transverse bars. The free tergites are dark-brown. Chelicerae and pedipalpi pale-yellow. Legs are greyish-brown. Coxae yellowish with darker pigmentation distally. Sternum and genital operculum with dark infuscation. Free sternites dark-brown with a transverse row of yellow dots.

Scutum (fig. 149) finely shagreened. Carapace furnished with a transverse row of four denticles above the anterior margin on each side. Eyemound broadly conical and armed with a short median spine. Scutal groove distinct. Other tergal grooves indistinct . Tergal Area II with a short transverse row of granules. Areas III and IV each with a pair of conical spines, those on Area IV being more widely spaced than those on Area III. Area V and each free tergite furnished with a transverse row of small tubercles.

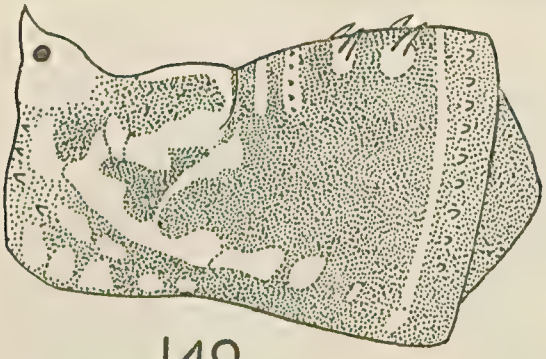
Chelicerae stout. The first segment is 0·86 mm. long. It has a dorsal bulge in the distal half and is unarmed. The second segment is 1·14 mm. long and armed with a median dorsal row of small tubercles and a prodorsal marginal row of three teeth, the middle tooth being the largest.

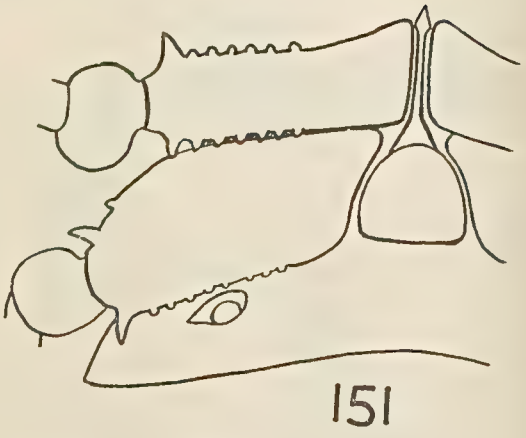
Pedipalpi (fig. 150) moderately strong. The trochanter armed with a single tooth below and two small prodorsal denticles above. The dorsal surface of the femur has a median row of four small denticles. The retrolateral surface is smooth. The prolateral surface has a large tooth in the distal half and a small tubercle at the apex. A small tooth is also present near the middle of the prodorsal margin. The ventral surface is armed with a large median proximal tooth, which has a small tubercle on its anterior surface. The retroventral margin has a row of four teeth, the first being the largest. The proventral margin is devoid of teeth. The patella has two small proventral teeth. The tibia has a row of four teeth on each side, the first and third tooth in each row being larger than the second and fourth. The tarsus is armed with four teeth on each side, the distal tooth being very small. The claw is about half the length of the segment.

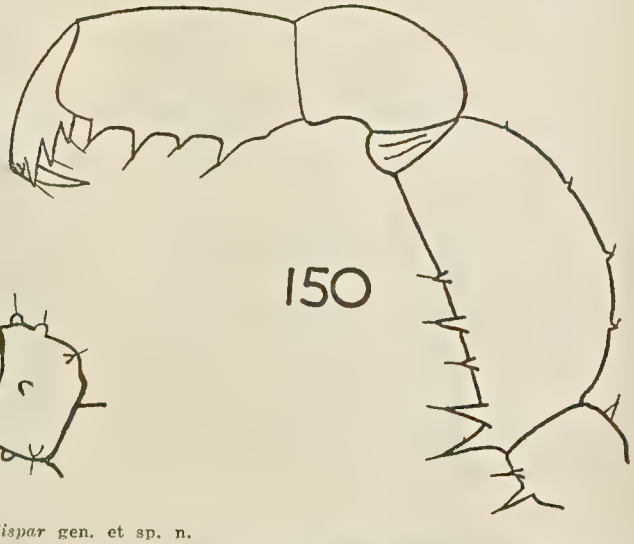
Coxe I is armed with three promarginal teeth, the middle tooth being the largest and the apical tooth deeply bifid. A few tubercles are present behind the promarginal teeth. Coxa II has a large tooth and several tubercles behind the apex and a broad tubercle above. Coxa III is furnished with a marginal row of granules in front and behind, the distal granule being enlarged into a tooth (fig. 151). Coxa IV is furnished with a tooth in front of and another behind the apex. It also has a row of granules along the posterior margin.

The sternum is long and narrow. The genital operculum is smooth and rounded in front. It measures 0·40 mm. in length and width. The respiratory spiracles are moderately large and conspicuous.

The legs are unarmed but the femora are slightly tuberculate (fig. 152). The calcaneus of







Nucina dispar gen. et sp. n.

FIG. 149.—Lateral view of scutum and free tergites of female.
FIG. 150.—Retrolateral view of pedipalpus of female.
FIG. 151.—Ventral view of right coxae III and IV, sternum, genital operculum, and spiracle of female.
FIG. 152.—Femur of leg I of female .

each metatarsus is straight and conical. It is much shorter than the astragalus. The number of segments in tarsi I-IV is 3, 11L 10R, 4, 4. Distitarsi I and II have two and three segments respectively. The claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

Locality: The holotype female was collected under a decaying log near the lighthouse at Table Cape, Wynyard, Tasmania, 24 August, 1954. It is the only specimen of the species in the collection.

Genus **STYLONUNCIA** gen. n.

Eyemound rises from the front margin. It is high, conical, inclined forward and produced into a short spine. The anterior margin of the carapace is armed above on each side with a transverse row of sharp spines. The scutal groove is shallow; the other tergal grooves absent. Each tergal Area and free tergite is furnished with a transverse row of granules but is without spines and large tubercles. The first segment of the chelicerae has a median dorsal spine at the apex but is without a proximal retrodorsal boss in the male. The sternum is long and narrow. The respiratory spiracles are concealed under bridging granules on the fourth coxae. The legs are unarmed but the femora are somewhat tuberculate. The calcaneus of each metatarsus is knob-like and much shorter than the astragalus. That of leg I in the male is not notched below. In the male tarsus I has four segments, in the female three. Tarsus II has 10-11 segments and tarsi III and IV each four segments. Distitarsi I and II have two and three segments respectively. The claws of tarsi III and IV are three-pronged, the median prong being larger than the lateral prongs.

Genotype: *Stylonuncia spinosa* sp. n.

Type Locality: Hellyer Gorge, Tasmania.

The genus *Stylonuncia* is near *Nucina* gen. n. but differs from the latter genus in the form of the eyemound, the presence of spines on the anterior margin of the carapace and the absence of spines on the tergal Areas.

STYLONUNCIA SPINOSA, sp. n.

(Figures 153-155)

Holotype Male

Measurements in millimeters: Body-length 3·71, length of scutum 3·54, length of carapace 1·77.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·91	0·51	2·28	0·91	1·71	2·28	1·20	9·80
Leg 2	1·31	0·57	3·03	1·14	2·34	3·08	2·46	13·93
Leg 3	1·14	0·51	2·00	0·97	1·71	2·57	1·26	10·16
Leg 4	1·66	0·69	3·03	1·20	2·34	3·65	1·54	14·11
Pedipalp	0·57	0·46	1·88	1·14	1·14	....	1·20	6·39

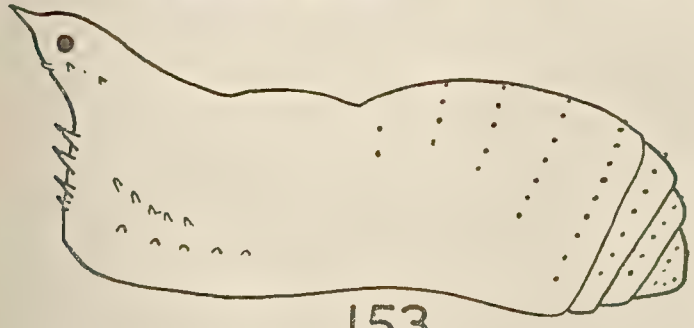
Colour (in alcohol): Body, chelicerae and pedipalpi yellowish-brown without any dark markings. Legs slightly darker than body.

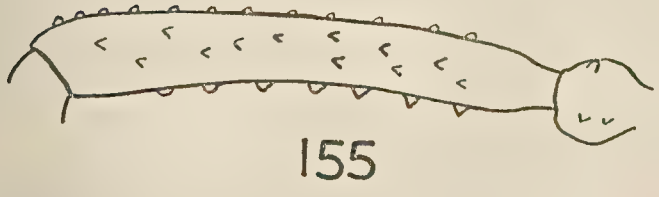
Scutum (fig. 153) armed with a transverse row of four sharp spines on each side above the anterior margin of the carapace, the two inner spines being larger than the two outer ones on each side. The eyemound rises from the front margin. It is high, conical, inclined forward and produced into a short spine. On each side of the carapace in the anterolateral angles and extending a short distance along the lateral ridge on each side of the scutum are two parallel rows of small denticles. The scutal groove is shallow; the other tergal grooves absent. Each tergal Area and free tergite is furnished with a transverse row of very small granules, but is without spines and large tubercles.

Chelicerae have a rather long basal segment measuring 1·14 mm. and armed with a median dorsal spine at the apex. The second segment is 1·66 mm. long and furnished with two spinous tubercles on the prodorsal margin and a median dorsal row of blunt tubercles.

Pedipalpi (fig. 154) moderately robust. Trochanter has a large spine and small tubercle below with three small tubercles above. The dorsal surface of the femur is armed with a median row of three teeth. The retrolateral surface has a row of about six small denticles above the ventral margin. The prolateral surface has two teeth in the distal half and a small denticle near the middle of the dorsal margin. The ventral surface is armed with a large median proximal tooth having a small tubercle on its posterior surface. The retroventral margin has a row of three teeth alternating with three small denticles. The proventral margin is furnished with a row of five small denticles. The patella has two small teeth on the prolateral side and a small tubercle below on the retrolateral side. The tibia is tuberculate below. On its retrolateral side it is armed with five teeth, of which the first and third are very small. On the prolateral side it is armed with four teeth, the first and fourth being much smaller than the other two. The tarsus has three teeth on each side. The claw is long, being nearly half the length of the segment.

Coxa I has a promarginal row of three teeth, the middle tooth being the largest. The apical tooth is so deeply bifid as to appear almost as two separate teeth. Coxa II is furnished with three blunt teeth and several granules behind the apex and with a broad tubercle above. Coxa III has a marginal row of granules in front and behind. Coxa IV has three small blunt teeth in front of





Stylonuncia spinosa gen. et sp. n.

Fig 153.—Lateral view of scutum and free tergites of male.
Fig. 154.—Retrolateral view of pedipalpus of male.
Fig. 155.—Femur of leg I of male.

the apex and a row of granules along the distal third of the posterior margin.

Sternum is long and narrow. The genital operculum has a smooth and rounded margin and measures 0·51 mm. long by 0·46 mm. wide. The respiratory spiracles are concealed by bridging granules on the posterior margin of the fourth coxae.

The legs are unarmed but the femora are somewhat tuberculate. The tubercles below the femora of the first pair of legs are coarser than on the other legs (fig. 155). The calcaneus of each metatarsus is knob-like and much shorter than the astragalus. All metatarsi exhibit pseudosegmentation. The number of segments in tarsi I-IV is 4, 11, 4, 4. Distitarsi I and II have two and three segments respectively. The claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

Allotype Female

Measurements in millimeters: Body-length 4·05, length of scutum 3·48, length of carapace 1·77.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·97	0·46	2·06	0·80	1·66	2·17	1·03	9·15
Leg 2	1·48	0·63	2·91	1·09	2·40	2·86	2·28	13·65
Leg 3	1·26	0·57	2·06	0·86	1·71	2·40	1·26	10·12
Leg 4	1·71	0·69	2·86	1·14	2·28	3·31	1·54	13·53
Pedipalp	0·46	0·46	1·66	1·03	1·20	....	1·03	5·84

There is little difference in size, colouration and general appearance between the female and male. The spine on the eyemound is shorter than in the male. The genital operculum measures 0·34 mm. long and 0·51 mm. wide. The tarsal segmentation is 3, 11L 10R, 4, 4.

Localities: The holotype male was collected under decaying logs at Hellyer Gorge, Tasmania, 25th August, 1954. The allotype female and one other female were found at Table Cape, Wynyard, Tasmania, 24th August, 1954.

Genus **MESTONIA** gen. n.

Front margin of scutum smooth. Eyemound high, conical and produced into a long horn or spine. Scutal groove and tergal grooves distinct medianly. Tergal Areas III-V and free tergites furnished with blunt tubercles. Sternum long and narrow; not crescentic posteriorly. Respiratory spiracles concealed under bridging granules on the posterior margin of the fourth coxae. Legs without spines but with blunt tubercles on femora, patellae and tibiae. Calcanei conical and much shorter than astragali. Tarsal segmentation: 3, 6-12, 4, 4. Distitarsi I and II with two and three segments respectively. Claws of tarsi III and IV three-pronged, the median prong being larger than the lateral prongs.

Genotype: *Mestonia picra* sp. n.

Type Locality: Mount Wellington, Tasmania.

In addition to the genotype one other species is assigned to the genus. The two species may be distinguished as follows:—

Eyemound near middle of carapace *Mestonia acris sp. n.*

Eyemound near front margin *Mestonia picra* sp. n.

MESTONIA PICRA sp. n.

(Figures 156-160)

Holotype Male

Measurements in millimeters: Body-length 2·68, length of scutum 1·94, length of carapace 1·09.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·57	0·34	1·43	0·57	0·97	1·31	0·63	5·82
Leg 2	0·86	0·51	2·23	0·69	1·60	2·17	1·43	9·49
Leg 3	1·03	9·34	1·60	0·69	1·20	1·88	0·69	7·43
Leg 4	1·31	0·40	2·06	0·80	1·54	2·97	0·74	9·82
Pedipalp	0·46	0·29	1·26	0·74	0·80	....	0·63	4·18

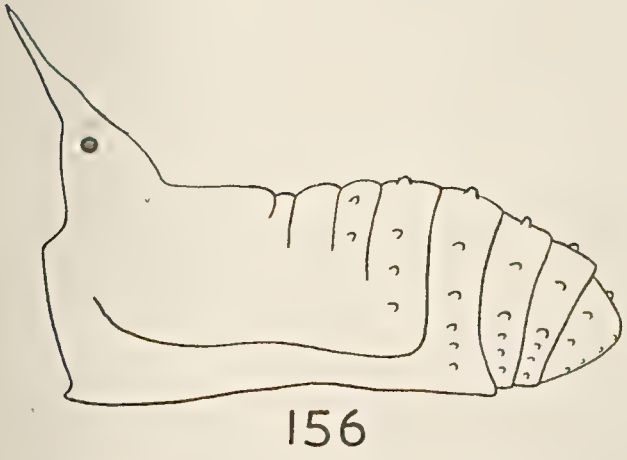
Colour (in alcohol): Carapace yellowish-brown with dark reticulations behind the eyemound and on each side. Rest of scutum dark-brown with lighter coloured margin. Free tergites dark-brown. Chelicerae, pedipalpi and coxae yellowish-brown with dark reticulations. Free sternites dark-brown. Legs brown, speckled with yellowish-brown.

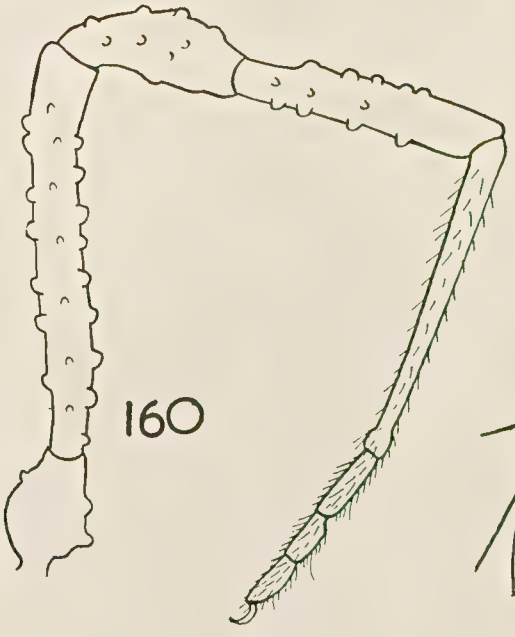
Scutum (fig. 156) finely shagreened. Front margin smooth. A transverse row of blunt tubercles on each of the tergal Areas III-V and on the free tergites. The tubercles decrease in size laterally. Scutal groove and tergal grooves distinct medianly. Eyemound rising from near the front margin in the form of a high cone, which is armed at the apex with a long sharp horn inclined slightly forwards.

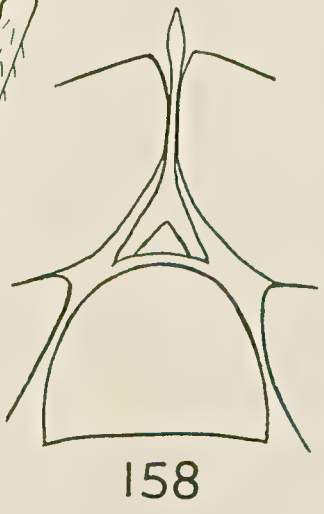
Chelicerae moderately strong. The first segment is 0·69 mm. long and has a small prodorsal tubercle at the apex. The second segment is 0·97 mm. long and is furnished with a row of four tubercles on the prodorsal margin, the third tubercle being larger and sharper than the others.

Pedipalpi (fig. 157) large and strong. The coxa has a pair of spinules below. Trochanter is armed with a large tooth below. The femur is much swollen and enlarged dorsoventrally in the proximal half. The dorsal surface is smooth, being devoid of spines and tubercles. The prolateral surface has two teeth in the distal half. The retrolateral surface is smooth. The ventral surface is armed with a large median proximal tooth. A row composed of one large tooth and three small denticles is present on both proventral and retroventral margins. Patella is armed with two prolateral teeth. The tibia is tuberculate below and has four retrolateral teeth, the first one being very small, and two prolateral teeth. The tarsus has three teeth on each side. The claw is nearly half the length of the segment.

Coxae shagreened. Coxa I with two small teeth on the promargin, one at the middle, the other at the apex. The apical tooth is so deeply bifid that it presents the appearance of two teeth close together. The ventral surface is furnished with a few conical tubercles. Coxa II has a few small







Mestonia picra gen. et sp. n.

FIG. 156.—Lateral view of scutum and free tergites of male.
FIG. 157.—Prolateral view of pedipalpus of male.
FIG. 158.—Sternum and genital operculum of male.
FIG. 159.—Ventral view of distal part of penis.
FIG. 160.—Leg I of male.

granules behind the apex. Coxa III is furnished with a marginal row of granules in front and behind. Coxa IV has a few granules in front of the apex and a row of granules along the posterior margin, the distal granules being enlarged to form bridging granules covering the spiracle.

Genital operculum smooth, rounded in front and measuring 0 34 mm. in length and width. The penis has the form shown in fig. 159. The ventral plate is not cleft and is armed with three pairs of inferior setae. Near the base of the ventral plate is a pair of leaf-like lateral processes, one on each side. In front of the lateral process on each side are three long setae. The dorsal plate is divided into two long narrow lobes, which extend forward, one on each side of the glans. The distal end of the glans is stout and rounded. It is provided above with a pair of hook-like apophyses.

The sternum (fig. 158) is long and narrow; not widely crescentic posteriorly. The respiratory spiracles are concealed under bridging granules on the fourth coxae.

The legs are unarmed but the femora, patellae and tibiae are tuberculate. In the case of leg I (fig. 160) the tubercles are coarser than on other legs. Calcanei are straight, conical and much shorter than the astragali. The number of segments in tarsi I-IV is 3, 8, 4, 4. Distitarsi I and II have two and three segments respectively. The claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

Allotype Female

Measurements in millimeters: Body-length 2·68, length of scutum 2·11, length of carapace 1·03.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·51	0·34	1·09	0·51	0·80	1·14	0·57	4·96
Leg 2	0·86	0·40	1·77	0·63	1·43	1·88	1·26	8·23
Leg 3	0·86	0·34	1·37	0·63	1·09	1·77	0·63	6·69
Leg 4	1·03	0 46	2·00	0·63	1·43	2·74	0·74	9·03
Pedipalp	0·34	0·29	0·86	0·63	0·69	....	0·57	3·38

The female resembles the male in colouration but the dark-brown pigmentation is more extensive. The pedipalpi are much smaller than those of the male. The genital operculum measures 0·29 mm. long and 0·46 mm. wide. The number of segments in tarsi I-IV is 3, 7, 4, 4.

Localities: The type specimens were collected from moss on Mount Wellington, Tasmania, 13th January, 1953. The species also occurs at Tarraleah, the Arve Forest at Geeveston and at National Park.

Variations: The collection contains 25 males and 26 females. The males vary in body-length from 2·28-2·74 mm. and the females from 2·26-2·97 mm. In some males the denticles on the proventral margin of the femur of the pedipalpus are reduced or absent. The number of segments in tarsi I, III and IV is 3, 4, 4, respectively in both sexes. The number of segments in tarsus II varies in males from 7-12 and in females from 6-10. Much asymmetry is exhibited by both sexes in the segmentation of tarsus II (see Table 13).

Table 13

Number of specimens	Sex	Number of segments in tarsus II
1	♂	7
2	♂	7L 8R
3	♂	8L 7R
10	♂	8
3	♂	8L 9R
1	♂	9L 8R
1	♂	9
1	♂	9L 12R
1	♂	10L 8R
1	♂	10
1	♂	11L 9R
2	♀	6L 7R
9	♀	7
2	♀	7L 8R
3	♀	8L 7R
3	♀	8
1	♀	8L 9R
1	♀	9L 7R
1	♀	9L 8R
3	♀	9
1	♀	10L 9R

MESTONIA ACRIS sp. n.

(Figures 161-165)

Holotype Male

Measurements in millimeters: Body-length 3·14, Length of scutum 2·57, length of carapace 1·31.

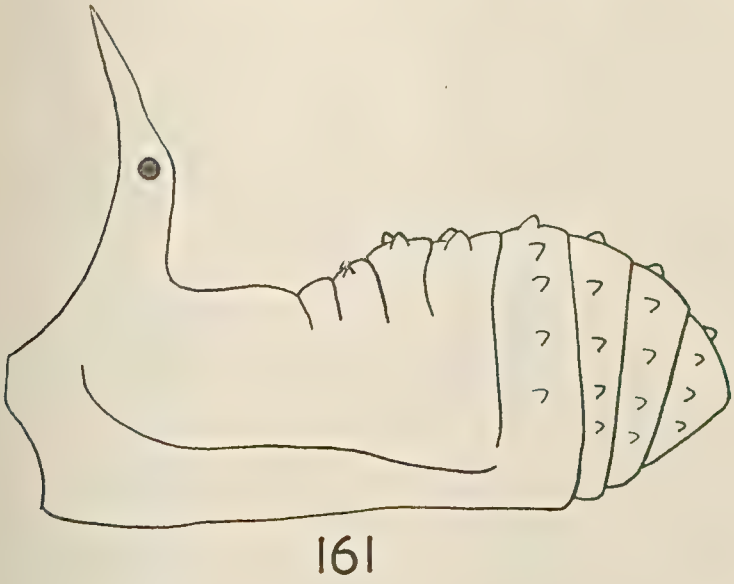
	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·97	0·46	1·71	0·74	1·43	1·77	0·97	8·05
Leg 2	1·43	0·57	2·80	0·91	2·28	2·74	2·17	12·90
Leg 3	1·08	0·51	2·00	0·80	1·49	2·28	1·03	9·19
Leg 4	1·26	0·57	2·40	0·91	1·94	3·31	1·26	11·65
Pedipalp	0·57	0·46	1·83	1·43	1·20	....	1·37	6·86

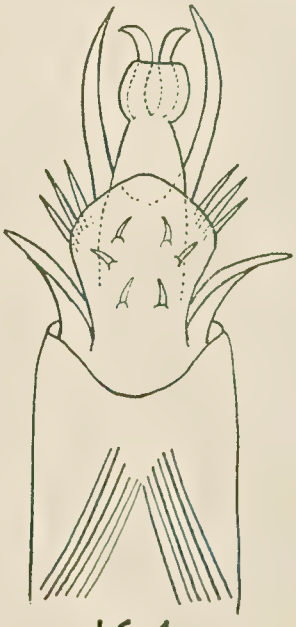
Colour (in alcohol): Carapace yellowish with dark reticulations on each side and on the front of the eyemound. A dark v-shaped mark is present immediately behind the eyemound. On each side of the posterior two-thirds of the scutum is a large dark-brown triangular area, the apex of which extends forwards to the sides of the carapace. The two dark-brown regions unite across tergal Area V, the median part of Areas I-IV being occupied by a U-shaped yellow region. The free tergites are dark-brown. Chelicerae and pedipalpi mainly yellowish with dark-brown reticulations, the femoral and tibial segments of the pedipalpi being dark-brown ventrally. The legs are brown, speckled with yellow. Coxae yellow with dark reticulations. Free sternites yellowish with brown pigmentation laterally and in the median line.

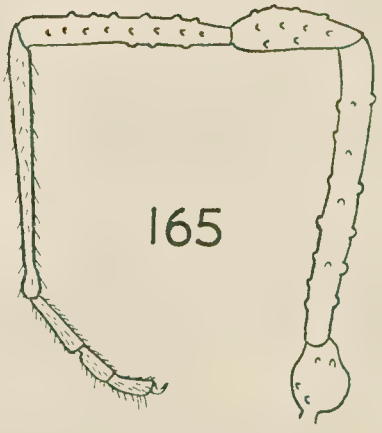
Scutum (fig. 161) finely shagreened and unarmed. Front margin smooth. A median pair of low blunt tubercles is present on each of tergal Areas II-IV, those on Area IV being larger and wider apart than those on Areas II and III. Tergal Area V and each free tergite have a transverse row of small conical tubercles. The eyemound is set back from the margin and situated almost in the middle of the carapace. It is high, conical and produced above into a long horn. Below the level of the eyes the eyemound is inclined slightly back-

ward but above the eyes the horn-like projection is inclined slightly forward. The height of the eye-mound including the horn is nearly equal to half the length of the scutum. The scutal groove and tergal grooves are distinct medianly. The fifth groove extends laterally almost to the scutal margin.

Chelicerae moderately strong. The first segment measures 0·63 mm. long and has a small blunt prodorsal tubercle at the apex. The second segment measures 1·08 mm. long and is armed with a row of three small tubercles on the prodorsal margin, the middle tubercle being the largest and dentiform.







Mestonia acris gen. et sp. n.

Fig. 161.—Lateral view of scutum and free tergites of male.
Fig. 162.—Prolateral view of pedipalpus of male.
Fig. 136.—Sternum of male.
Fig. 164.—Ventral view of distal part of penis.

Pedipalpi (fig. 162) large and strong. The coxa has a small tubercle below. The trochanter is armed with a large ventral tooth. The femur is swollen and in the proximal half is much enlarged dorsoventrally. Two small denticles are present in the median dorsal line. The retrolateral surface has a small conical tubercle below in the proximal half. The prolateral surface is furnished with two small tubercles below in the distal half and a third small tubercle near the middle of the surface. The ventral surface is armed with a large median proximal tooth. On the retroventral margin is a row composed of three teeth and two granules, the first and third teeth being larger than the second. The proventral margin is armed with three teeth, the second of which is in the form of a very large blunt peg, which projects inward. The tibia is slightly tuberculate below and has a prolateral row of three teeth, the two distal teeth being close together near the apex. The retrolateral side is armed with a row of four teeth, the first tooth being very small. The tarsus has three teeth on each side. The tarsal claw is about one-third the length of the segment.

The coxae are finely shagreened. Coxa I has a promarginal row of three teeth, the middle tooth being the largest. The apical tooth is deeply bifid. Coxa II is armed with a small conical tooth behind the apex and a large broad tubercle above. Coxa IV is furnished with several small granules in front of the apex and a row of granules along the posterior margin.

Genital operculum smooth and rounded in front. It measures 0·46 mm. in length and width. The penis has the form shown in fig. 164. It clasely resembles that of the preceding species *Mestonia picra*.

The sternum (fig. 163) is long and narrow and does not form a wide crescent posteriorly. The respiratory spiracles are concealed by the posterior margin of the fourth coxae.

Legs slender and unarmed but the femora, patellae and tibiae are slightly tuberculate (fig. 165). All calcanei are straight, conical and short, being much shorter than the astragali. The number of segments in tarsi I-IV is 3, 12L 11R, 4, 4. The distitarsi I and II have two and three segments respectively. The claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

Allotype Female

Measurements in millimeters: Body-length 3·43, length of scutum 2·28, length of carapace 1·14.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·80	0·34	1·43	0·63	1·14	1·54	0·86	6·74
Leg 2	1·14	0·46	2·28	0·86	2·00	2·46	1·77	10·97
Leg 3	1·03	0·40	1·77	0·69	1·37	2·11	1·03	8·40
Leg 4	1·20	0·51	2·28	0·86	1·77	3·03	1·09	10·74
Pedipalp	0·40	0·34	1·26	1·09	1·03	....	0·97	5·09

The female resembles the male in colouration but the dark-brown pigmentation is more extensive. The pedipalpi are much smaller than those of the male and the femur lacks the large peg-like promarginal tooth on the ventral surface, its place being taken by a small denticle. The genital operculum is smooth and rounded in front. It measures 0·46 mm. long and 0·51 mm. wide. The number of segments in tarsi I-IV is 3, 12L 10R, 4, 4.

Localities: The type specimens were found under decaying logs on Mount Wellington. Tasmania, 30th November, 1955. The species also occurs at National Park, in the Arve Forest at Geeveston and in Myrtle Forest at Collinsvale.

Variations: The species is not common and the collection contains only nine males and two females. The males vary in body-length from 2·68-3·37 and females from 2·90-3·37 mm. Both sexes have three segments in tarsus I and four in tarsi III and IV. The number of segments in tarsus II varies from 10-14 in the males and 10-12 in the females. Nine of the 11 specimens are asymmetrical.

Genus **MONOXYOMMA** Pocock, 1903

Anterior margin of carapace with a few spines above on each side. Eyemound conical and armed with a high spine or horn. Tergal Area III with a median pair of large spines. Other tergal Areas and the free tergites each with a transverse row of tubercles. Legs more or less granular and either with or without spines on the trochanter and femur of leg I. Calcaneus of each metatarsus shorter than astragalus. Number of segments in tarsi I and II variable. Tarsus I with 4-7, tarsus II with 9-22, tarsi III and IV with four each. Distitarsi I and II usually with two and three segments respectively. Claws of tarsi III and IV three-pronged, the middle prong being larger than the lateral prongs.

Genotype: *Monoxyomma spinatum* Pocock.

Type Locality: Hill Grove, New South Wales.

In its present restricted sense the genus *Monoxyomma* contains only three species, namely the genotype from New South Wales together with *M. manicatum* Roewer and *M. rotundum* Forster, both from Queensland. Two new species from Tasmania are described in the present paper. The five species may be distinguished by the following key.

KEY TO SPECIES IN THE GENUS *MONOXYOMMA*

1. Apical spine of eyemound half the height of the eyemound proper .... *M. rotundum* Forster.
   Apical spine of eyemound at least the height of the eyemound proper 2
2. Calcaneus of leg I of male hooked 3
   Calcaneus of leg I of male not hooked 4
3. Frontal margin of carapace with 4-5 denticles on each side .... *M. spinatum* Pocock.
   Frontal margin of carapace with only one denticle on each side .... *M. manicatum* Roewer.
4. Horn of eyemound inclined forward .... *M. silvaticum* sp. n.
   Horn of eyemound erect .... *M. cavaticum* sp. n.

MONOXYOMMA SILVATICUM sp. n.

(Figures 166-169)

Holotype Male

Measurements in millimeters: Body-length 5·25, length of scutum 4·28, length of carapace 2·28.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	1·26	0·69	3·31	1·20	2·57	3·60	1·94	14·57
Leg 2	2·17	0·80	4·91	1·60	4·28	5·14	4·85	23·75
Leg 3	1·71	0·74	3·14	1·31	2·68	4·00	2·34	15·92
Leg 4	2·11	0·86	4·68	1·43	3·31	6·17	3·08	21·64
Pedi-palp	0·69	0·63	2·97	2·00	2·11	....	1·88	10·28

Colour (in alcohol): Scutum reddish-brown with dark-brown reticulations on each side of carapace and round the base of the eyemound. A large light-brown saddle-shaped area is present on the posterior half of the scutum. The two sides of the saddle-shaped area are separated by a median dark- brown wedge-shaped mark extending from the scutal groove to the posterior margin of the scutum. The free tergites are dark-brown. Chelicerae and pedipalpi are light-brown with dark reticulations. Legs are dark-brown speckled with light-brown. Ventral surface of body mainly reddish-brown. The free sternites are margined with dark-brown posteriorly.

Scutum (fig. 166) is furnished with three denticles on each side above the anterior margin and a row of four granules on each side of the carapace. The eyemound is conical and rises from close behind the anterior margin. It is produced above into a large spine or horn, which is inclined slightly forward. The scutal groove is distinct medianly; the other tergal grooves indistinct. A median pair of small deticles is present in the scutal groove and a transverse row of denticles on Areas II-IV, the rows increasing in length posteriorly. The median pair of denticles on Areas III and V is enlarged to form conspicuous blunt spines, the pair on Area III being larger than the pair on Area V. Each free tergite has a transverse row of small denticles, the median pair of denticles in each row being larger than the others and having a small granule midway between them.

Chelicerae (fig. 167) are moderately strong. The first segment is 1·37 mm. long and has a small median tooth on the dorsal side at the apex. The second segment is 2·17 mm.. long and has two tubercles on the prodorsal margin, the second tubercle being large, tooth-like and near the middle of the margin.

Pedipalpi (fig. 168) large and strong. Trochanter has a small tooth above and two larger teeth below, one being ventral, the other prolateral. The dorsal surface of the femur is armed with a median row of five teeth, the first two being larger than the others. The retrolateral surface has a row of four small denticles above the ventral margin. The prolateral surface is furnished with two conical tubercles in the distal third and a row of about five denticles near the prodorsal margin. The ventral surface is armed at the base with a large median bifid tooth, which is inclined inwards and has a small tubercle on its anterior surface and another on its posterior surface. The retroventral margin has a row of three teeth, the first of which is the largest. The proventral margin is provided with a row of about five small denticles. The patella is armed with two prolateral teeth. The tibia is slightly tuberculate below and is armed with four retrolateral and three prolateral teeth. The tarsus has three teeth on each side. The claw is about one-third the length of the segment.

Coxa I has a promarginal row of three teeth, the middle tooth being the largest and the apical tooth deeply bifid. A few conical tubercles are present behind the promarginal teeth. Coxa II has two teeth behind the apex and a coarse tubercle above. Coxa III is furnished with a few granules behind the distal end, but otherwise lacks the marginal rows of granules, which are usually present in other species. Coxa IV has a short tooth and a few small tubercles in front of the apex and a few granules on the distal half of the posterior margin.

The sternum is long and narrow. The genital operculum has a smooth rounded margin and measures 0·57 mm. in length and width. The respiratory spiracles are small but not concealed.

The legs rather long and slender. They are unarmed but the femora, patellae and tibiae are somewhat tuberculate. The calcaneus of each metatarsus is conical, straight and much shorter than the astragalus. The calcaneus of leg I is not notched below and is about 1/6 the length of the metatarsus. The number of segments in tarsi I-IV is 5L 6R, 18, 4, 4. Distitarsi I and II have two and four segments respectively. The claws of tarsi III and IV are three-pronged the middle prong being larger than the lateral prongs.

Allotype Female

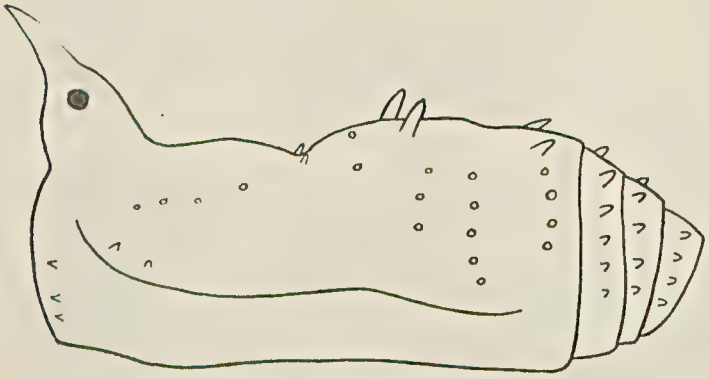
Measurements in millimeters: Body-length 4·68, length of scutum 3·48, length of carapace 1·66.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	1·03	0·57	2·74	1·03	2·34	3·03	2·00	12·74
Leg 2	1·77	0·69	4·40	1·37	3·03	4·68	4·57	20·51
Leg 3	1·60	0·69	2·91	1·20	2·28	3·54	2·23	14·45
Leg 4	2·00	0·86	4·57	1·31	2·86	5·54	2·68	19·82
Pedi. palp	0·63	0·57	2·00	1·14	1·43	....	1·31	7·08

The female resembles the male in colouration but lacks the saddle-shaped region on the scutum. The pedipalpi (fig. 169) are smaller than those of the male and the proximal ventral tooth on the femur is not bifid. The number of segments in tarsi I-IV is 4, 13, 4, 4. Distitarsi I and II have two and three segments respectively. The genital operculum is 0·51 mm. long and 0·57 mm. wide.

Localities: The type specimens were collected under decaying logs in *Notofagus* forest near Weldborough Pass, Tasmania, 16th April, 1954. The species also occurs at St. Columba Falls in the neighbouring district of Pyengana.

Variations: The species is not common and the collection contains, in addition to the type specimens, only one other male and female. In the male the segmentation of tarsi I-IV is 5, 18, 4, 4 and of distitarsi I and II it is two and five respectively. In the female the segmentation of tarsi I-IV is 5L 4R, 15, 4, 4. The distitarsus of leg I has two segments and is symmetrical but that of leg II has four segments on the left side and five on the right.



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Monoxyomma silvaticum sp. n.

FIG. 166.—Lateral view of scutum and free tergites of male.
FIG. 167.—Prolateral view of chelicera of male.
FIG. 168.—Prolateral view of pedipalpus of male.
FIG. 169.—Prolateral view of pedipalpus of female.

MONOXYOMMA CAVATICUM sp. n.
(Figures 170-173)

Holotype Male

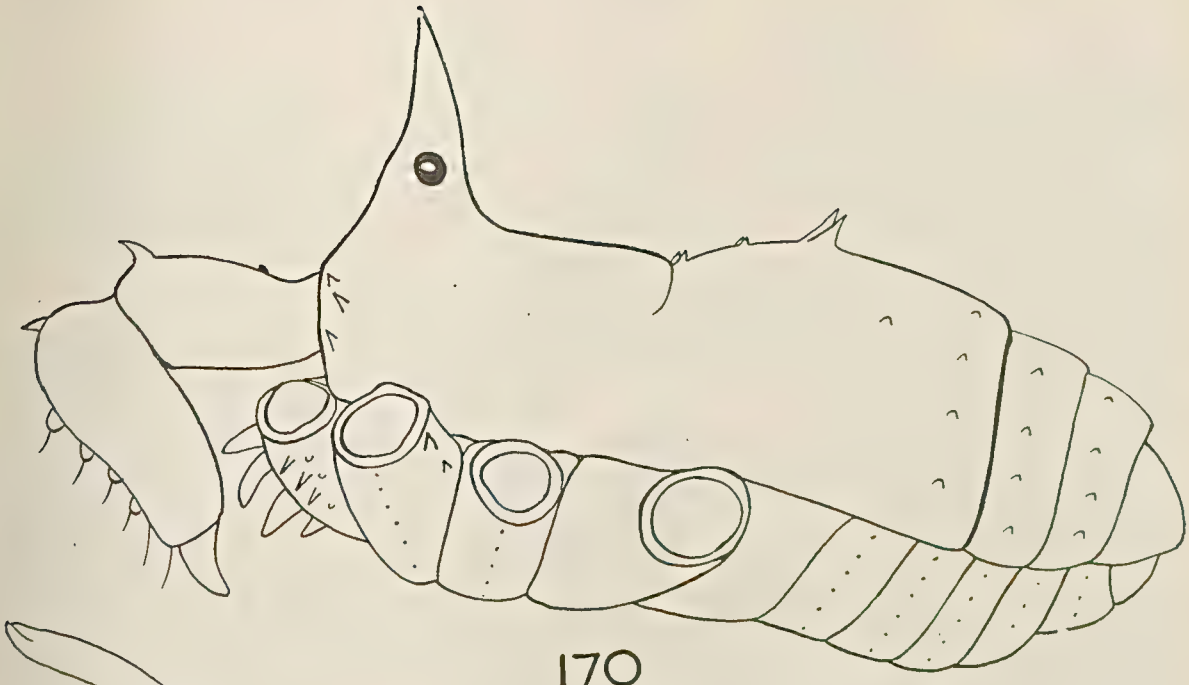
Measurements in millimeters: Body-length 7·65, length of scutum 5·42, length of carapace 2·50.

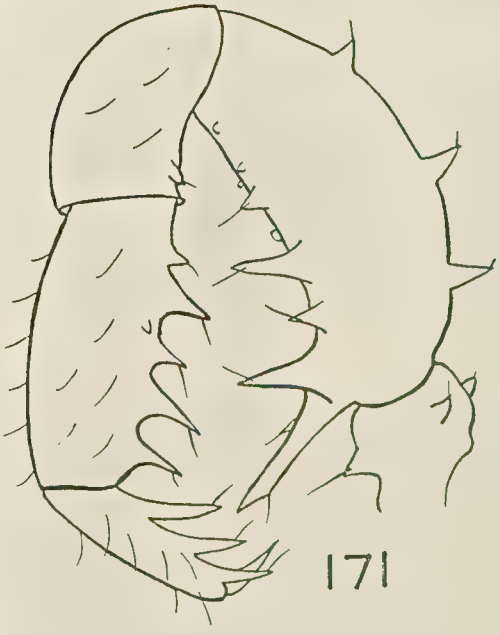
	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	1·81	0·97	5·98	1·67	4·87	6·67	2·92	24·89
Leg 2	2·78	1·25	10·43	2·09	8·62	10·84	10·15	46·16
Leg 3	2·50	1·11	6·53	1·67	4·87	8·20	3·34	28·22
Leg 4	2·78	1·39	10·29	2·36	5·98	12·51	5·00	40·31
Pedipalp	1·25	0·83	3·48	2·22	2·64	....	2·09	12·51

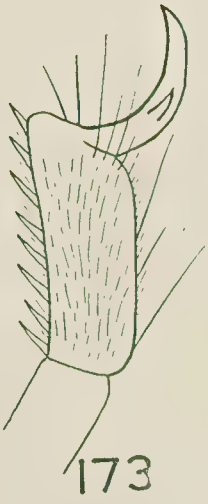
Colour (in alcohol): Dorsal surface of body, chelicerae and pedipalpi yellowish-brown. Legs yellowish with paler tarsi. Ventral surface of body yellowish-brown.

Surface of scutum finely granular. Anterior margin with a row of three small denticles above on each side. Eyemound high, conical, situated about half its basal diameter from the front margin and surmounted by a long sharp erect horn (fig. 170). It rises steeply both in front and behind. Scutal groove distinct and deep medianly. Tergal grooves not distinct. Areas I and II each furnished with a median pair of small denticles. Area III is raised and forms the highest part of the abdominal scutum. It is provided with a median pair of spines. Area IV has a widely separated pair of small denticles. Area V and the free tergites are each provided with a transverse row of small rounded tubercles.

Chelicerae strong. The basal segment has a single spine near the apex of the dorsal surface







Monoxyomma cavaticum sp. n.

FIG. 170.—Lateral view of body and chelicera of male.
FIG. 171.—Retrolateral view of pedipalpus of male.
FIG. 172.—Lateral view of penis.
FIG. 173.—Distal tarsal segment and claw of leg III.

and a smaller denticle near the middle. The second segment has two teeth and several smaller tubercles on the dorsal surface (front).

Pedipalpi large and powerful. Coxa with one ventral spine, trochanter with two small spines above and one below. Femur has a median row of three teeth above. The prolateral surface is armed with a row of three spines above and two larger spines below near the apex. The ventral surface has a large basal spine which slopes backward and has a small accessory tooth on its mesial surface. The retroventral margin is armed with a row of four teeth, the first and third being larger than the other two (fig. 171). There are also a few small tubercles on the ventral surface. Patella has two large prolateral spines and a small retrolateral tooth. The tibia is armed with three prolateral teeth and five retrolateral teeth. The tarsus has three teeth on each side.

The coxae and abdominal sternites are finely granular. Coxa I has a promarginal row of three large teeth, the apical tooth being bifid. Behind the promarginal teeth there are three smaller teeth and several tubercles on the ventral surface. Coxae II, III and IV each have a median row of small setose granules on the ventral surface. Coxa II is armed with two small teeth behind the distal end. Coxa III is furnished with a marginal row of granules in front and behind. Coxa IV is unarmed in front but is furnished with a few granules on the posterior margin.

The sternum is narrow and not crescentic posteriorly. The genital operculum is small with a rounded and smooth margin. The penis has the form shown in fig. 172. The glans ends in a slender terminal process with a slightly expanded tip, which is divided by a short cleft into dorsal and ventral lobes. Above the glans is a bifid dorsal process, which, in the fully extended condition, is curved backwards. The ventral plate is deeply cleft and has two pairs of superior and three pairs of inferior setae. On each side of the basal part of the ventral plate is a small curved lateral plate, which is folded back against the corpus penis. When the organ is not fully extended the glans is withdrawn into the end of the corpus penis. In this condition the bifid dorsal lobe, the lateral plates and the ventral plate are all bent forwards and rest against the glans, only the ends of the various structures being visible.

The legs are long and slender. Trochanters I, II and III each have two or three small denticles, but segments beyond the trochanters are unarmed. All the femora are somewhat granular. Each calcaneus is straight and shorter than the astragalus. The calcanei of legs I-IV are about ¼, 3/11, 1/5 and ⅛ the lengths of the respective metatarsi. The number of segments in tarsi I-IV is 6, 18L 20R, 4, 4. The distitarsi I and II have two and three segments respectively. The tarsal claws are long and slender. Those of tarsi III and IV are three-pronged, the middle prong being much longer and stouter than the lateral prongs. Some of the setae on the ventral surface of the tarsi are coarse and spine-like (see fig. 173). The metatarsi exhibit pseudosegmentation.

The free abdominal sternites are each furnished with a transverse row of granules. The respiratory spiracles are close to the fourth coxae but not concealed.

Allotype Female

Measurements in millimeters: Body-length 7·78, length of scutum 4·86, length of carapace 2·22.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	1·81	0·70	5·56	1·67	4·45	6·53	3·34	24·06
Leg 2	2·50	1·11	10·01	2·09	8·34	10·43	9·31	43·79
Leg 3	2·36	1·11	6·67	1·67	4·59	7·92	4·17	28·49
Leg 4	2·78	1·25	9·73	1·95	5·28	11·81	4·87	37·67
Pedipalp	1·11	0·70	2·64	1·53	2·09	...	1·67	9·74

The female resembles the male in size, colouration and general features. The pedipalpi, however, are smaller and less robust. The median proximal tooth on the ventral surface of the femur lacks the small accessory tooth present in the male. The number of segments in tarsi I-IV is 5, 18, 4, 4. Distitarsi I and II have two and three segments respectively.

Locality: The type specimens were found in the Ida Bay Caves, Hastings, Tasmania, 22nd November, 1939. The harvestman lives in almost complete darkness and occurs on the moist walls of the cave about 400 yards from the entrance. It is associated with the luminous larvae of the mycetophilid fly, *Arachnocampa tasmaniensis* Ferguson. These larvae emit a pale bluish light in the otherwise quite dark cave.

Variations: The collection contains four adult males and three adult females together with six immature specimens. The body-length of the adult males varies from 5·68-7·65 mm. and of the adult females from 5·80-7·83 mm. The number of segments in tarsus I varies from six to seven in the males and from four to five in the females. In tarsus II it varies from 18-22 in the males and 16-21 in the females (see Table 14). Tarsi III and IV each have four segments in both sexes.

Table 14

Number of specimens	Sex	Number of segments in tarsus I	Number of segments in tarsus II
1	♂	6	18L 19R
1	♂	6	18L 20R
1	♂	7	19L 22R
1	♂	7	20L 19R
1	♀	4	19L 16R
1	♀	5	18
1	♀	5	21L 19R

Subfamily TRIAENOBUNINAE (Pocock)

The Opiliones belonging to this subfamily are characterized by having the posterior part of the sternum wide and crescentic. In most species, but not in all, the respiratory spiracles are concealed under bridging granules on the posterior margin of the fourth coxae.

Roewer (1923) in his great work "*Die Weberknechte der Erde*" mentions only six genera with seven species as belonging to the subfamily. Five of the genera are from Tasmania and the sixth

KEY TO TASMANIAN GENERA OF THE SUBFAMILY TRIAENOBUNINAE

1. Eyemound in the form of a trident ..... *Triaenobunus* Soerensen
   Eyemound not so constructed 2
2. Eyemound conical, armed with a spine or horn 3
   Eyemound conical and unarmed 9
3. A granule pattern on scutum ..... *Glyptobunus* Roewer
   No granule pattern on scutum 4
4. Femur of leg I armed below with spines ..... *Phoxobunus* gen. n.
   Femur of leg I unarmed 5
5. Front margin of scutum not armed above with spines 6
   Front margin of scutum armed above with two or more spines 8
6. Segment I of chelicerae with a long apical spine ..... *Eubunus* gen. n.
   Segment I of chelicerae without a long apical spine 7
7. Tergal Areas I-IV with a median pair of granules ..... *Allobunus* gen. n.
   Tergal Areas I, III and IV with a pair of spines ..... *Chilobunus* gen. n.
8. Front margin of scutum with a short spine above on each side ..... *Rhynchobunus* gen. n.
   Front margin of scutum with four spines above on each side ..... *Phanerobunus* Roewer.
9. Tarsus of leg II with four segments ..... *Miobunus* Roewer.
   Tarsus of leg II with more than four segments 10
10. Tarsus of leg II with five segments ..... *Tasmanobunus* gen. n.
    Tarsus of leg II with more than five segments 11
11. Tarsus of leg II with six segments ..... *Chrestobunus* Roewer.
    Tarsus of leg II with 9-11 segments ..... *Thelbunus* gen. n.

from the Australian mainland. Since 1923 several new genera from New Zealand have been included in the subfamily. However, Forster (1954, p. 15) from a study of the New Zealand species considers that the subfamily should be regarded merely as a *tribe* of the Triaenonychinae. Until more is known of the genital anatomy and biology of the Australian species it is not possible to make an adequate comparison with the New Zealand forms. The subfamily is therefore retained with its original status in the present paper, and a key to Tasmanian genera given at head of page.

Genus **TRIAENOBUNUS** Soerensen, 1886

Eyemound conical, arising from the front margin, directed upwards and forwards, and ending in the form of a three-pronged projection or trident. Scutum somewhat depressed, the front margin being armed on each side with blunt tubercles or sharp spines. Tergal grooves indistinct. Tergal Areas I-IV with a median pair of short spines. Area V and the free tergites each with a transverse row of conical tubercles. Pedipalpi armed with strong spines and tubercles. Legs armed with spines or tubercles on coxae, trochanters, femora, patellae and tibiae. The first leg is more strongly armed than the others. Calcaneus of each metatarsus short and knob-like. Respiratory spiracles concealed.

Genotype: *Triaenobunus bicarinatus* Soerensen.

Type Locality: Near Sydney, New South Wales.

The tarsal segmentation of the genotype is 3, 5, 3, 3 and this is often included in the definition of the genus, although it was not so included by Scerensen. Because of a different tarsal segmentation (3, 6, 4, 4) the Tasmanian species, *Triaenobunus pectinatus* Pocock, was removed from *Triaenobunus* by Roewer (1914, p. 157) and made the type of a new genus, *Peckhamius*. Recently, however, Forster (1955, p. 402) has placed five new species from the Australian mainland in the genus *Triaenobunus* and no two of them agree in having the same tarsal formula, nor has any one of them the same tarsal formula as the genotype. It would therefore appear that the tarsal segmentation in *Triaenobunus* has little value as a generic character. This being so it seems desirable to restore *Peckhamius pectinatus* to the genus *Triaenobunus*, where it was originally placed by Pocock.

In the present paper six new Tasmanian species have been included in the genus and a key to all the species is given hereunder.

KEY TO SPECIES IN THE GENUS *TRIAENOBUNUS*

1. Front margin of scutum without spines ..... *T. pescotti* Forster.
   Front margin of scutum with spines 2
2. Scutum without pattern of granules ..... *T. inornatus* sp. n.
   Scutum with a pattern of granules 3
3. Spines and tubercles on body pilose ..... *T. pilosus* sp. n.
   Spines and tubercles on body not pilose 4
4. Basiventral spine on femur of pedipalp trifurcate ..... *T. asper* sp. n.
   Basiventral spine on femur of pedipalp not trifurcate 5
5. Tarsus of leg I with two segments 6
   Tarsus of leg I with three segments 9
6. Pedipalp granulose ..... *T. armstrongi* Forster.
   Pedipalp not granulose 7
7. Eyemound without dorsal granules ..... *T. montanus sp. n.*
   Eyemound with dorsal granules 8
8. Middle prong of trident with granules ..... *T. cornutus* sp. n.
   Middle prong of trident without granules ..... *T. mestoni* sp. n.
9. Tarsi III and IV each with three segments ..... *T. bicarinatus* Soerensen.
   Tarsi III and IV each with four segments 10
10. Genital operculum smooth 11
    Genital operculum with tubercles or granules 12
11. Scutal pattern poorly developed ..... *T. minutus* Forster.
    Scutal pattern well developed ..... *T. groomi* Forster.
12. Leg I with small tubercles below trochanter ..... *T. pectinatus* Pocock.
    Leg I with long spines below trochanter ..... *T. woodwardi* Forster.

Of the species mentioned in the above key *T. pescotti T. bicarinatus* and *T. armstrongi* are from New South Wales, *T. minutus, T. woodwardi* and *T. groomi* are from Quensland and all the others are from Tasmania.

TRIAENOBUNUS PECTINATUS Pocock

(Figures 174-178)

This species was first recorded from Tasmania by Pocock (1903, p. 400) and described from a single specimen without the sex being mentioned. Roewer (1914, p. 157) in establishing the genus *Peckhamius* gave a further description based on a single male specimen from this State. The opilionid is one of the most common species found in the south-east quarter of Tasmania and the collection before me contains a large number of specimens. The following description adds some further details to the known features of the species.

Male

Measurements in millimeters: Body-length 4·85, length of scutum 4·00, length of carapace 2·11.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	1·14	0·68	1·54	0·80	1·08	1·37	0·74	7·35
Leg 2	1·71	0·74	2·63	1·43	1·94	2·51	1·60	12·56
Leg 3	1·65	0·68	1·54	0·86	1·37	1·88	0·86	8·84
Leg 4	2·46	0·80	2·23	1·14	2·00	2·91	1·03	12·57
Pedipalp	0·68	0·40	1·03	0·86	0·74	....	0·63	4·34

Colour (in alcohol): Dorsal surface of body dark-brown with a yellowish-brown saddle-shaped area in the middle of the scutum. Chelicerae and pedipalpi pale-brown with dark-brown reticulations. Legs dark-brown with a yellowish band on all femora and on the third and fourth tibiae and metatarsi. Trochanters yellowish. Sternum ,genital operculum and bases of coxae yellowish-brown. Sternites and anal operculum dark-brown.

Scutum (fig. 174) with a row of about six sharp spines on each side above the front margin. The three outermost spines usually consisting of two large spines with a small one between them. Eyemound arising from the front margin, conical, and extending forward in the form of a three-pronged projection or trident. The two lateral prongs are shorter than the median prong and behind each is a small spine followed by a larger spine near the base of the eyemound. Dorsal surface of eyemound furnished with granules. The surface of the scutum is decorated with a pattern of lobed granules, each of which measures about 0·135 mm. high, 0·111 mm. wide at the apex and 0·069 mm. wide at the base. The apex of the granule is somewhat flat and divided into four or five lobes, one of which bears a small seta (fig. 175). The scutal groove is distinct in the middle only. Tergal grooves are indistinct but their positions are indicated by transverse rows of lobed granules. A median pair of small spines is present on each of the tergal Areas I-IV. On Area V and each free tergite there is an anterior and posterior marginal row of lobed granules and between the two rows a transverse row of conical tubercles. The two spines, which in the figure given by Roewer (1914, p. 158, fig. 50*a*) are shown as situated on each side in Areas I-IV, are sometimes present and sometimes absent, or present on one side and not on the other.

The chelicerae are small. A dorsal apical tubercle is present on the basal segment and a dorsal longitudinal row of three small tubercles on the second segment.

The pedipalpi (fig. 176) are slightly longer than the scutum. The femur is armed with a prodorsal row of about five small teeth, a large proximoventral bifid tooth and two large retroventral teeth, one near the base the other near the apex. In some specimens but not in all there is also a proventral row of five minute tubercles. Patella tuberculate above. Tibia tuberculate above and below, with two small denticles on each side. Tarsus with three small teeth on each side.

Large tubercles are present on the distal half of the ventral surface of coxa I, on the anterior margin and behind the apex of coxa II, and in front of the apex of coxa IV. Small rounded tubercles are present on the ventral surfaces of all coxae and on the dorsal surface of coxa IV. Two transverse rows of small tubercles are present on each sternite but the anterior row is generally hidden by the posterior margin of the preceding segment. The genital operculum measures 0·51 mm. wide and 0·46 mm. from base to apex. Its anterior margin is rebordered, and its ventral surface furnished with a few tubercles. The form of the distal end of the fully extended penis is shown in fig. 177. The basal plate has three pairs of inferior and two pairs of superior setae. The dorsolateral plates are in the form of backwardly curved hooks. The distal part of the glans forms a dorsal and a ventral lobe.

The legs are provided with spinous tubercles on all the trochanters and femora and with smaller conical tubercles on patellae and tibiae. Leg I (fig. 178) is more strongly armed than the other legs. Its femur has a dorsal row of about 10 large spines, a retrolateral row of three large spines in the basal half and several smaller spines in the apical half, a proventral row of four large spines in the basal half and a retroventral row of six large spines and several smaller ones. Calcaneus of each metatarsus small and knob-like. Tarsal segmentation: 3, 6, 4, 4.

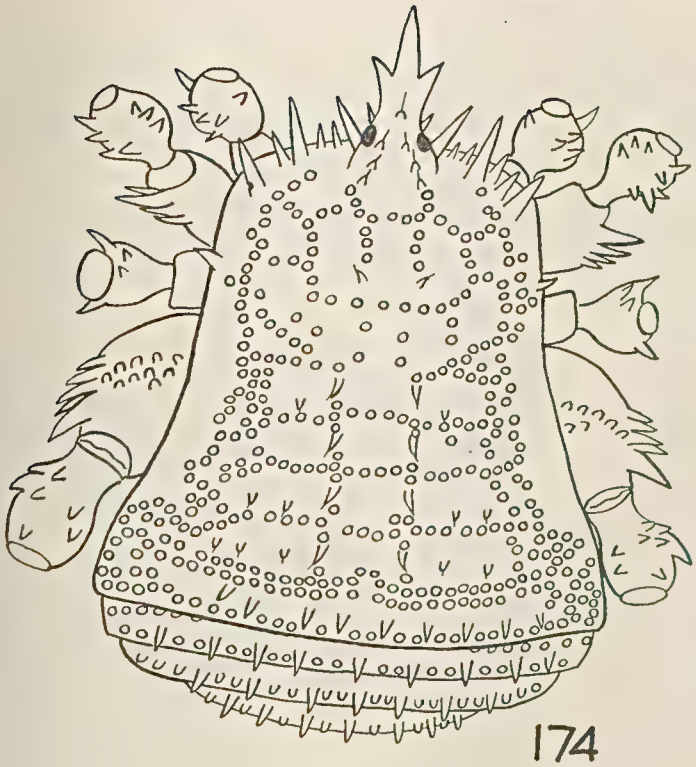
Female

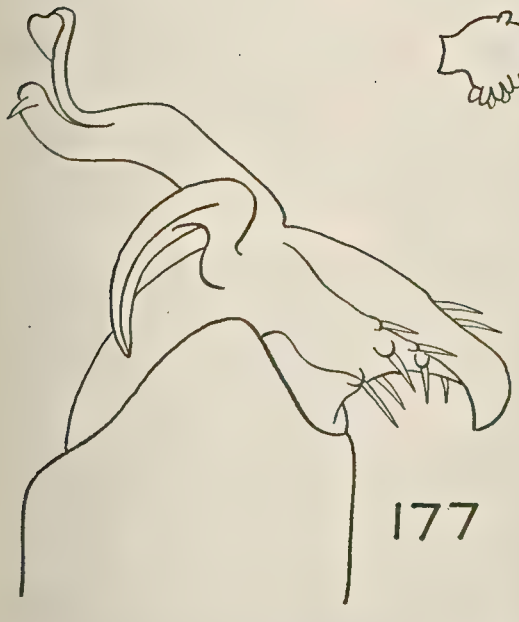
Measurements in millimeters: Body-length 4·11, length of scutum 3·30, length of carapace 1·60.

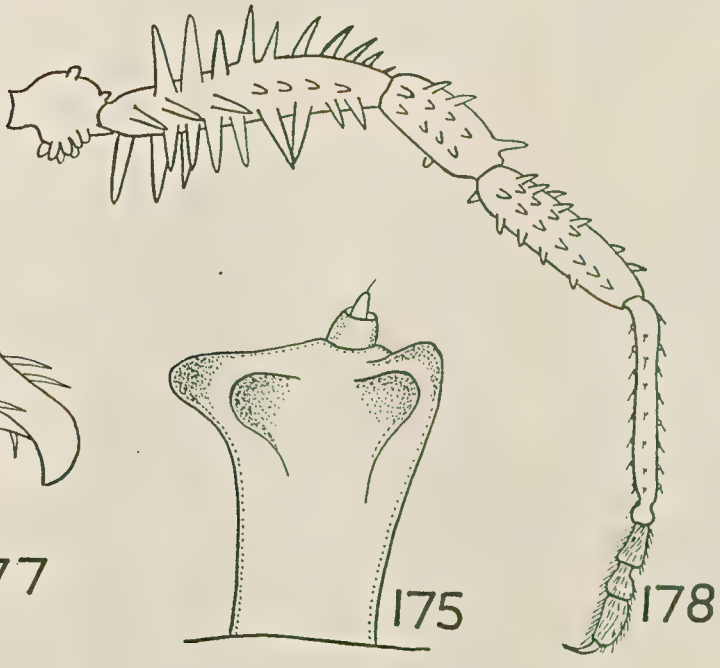
	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·86	0·34	1·26	0·68	0·86	1·09	0·63	5·72
Leg 2	1·43	0·57	1·94	1·14	1·54	1·88	1·31	9·81
Leg 3	1·37	0·51	1·14	0·69	1·20	1·37	0·69	6·97
Leg 4	1·94	0·74	1·71	0·86	1·60	2·28	0·97	10·10
Pedipalp	0·57	0·29	0·86	0·57	0·63	....	0·57	3·49

The female resembles the male but is slightly smaller. The pedipalpi are shorter and less robust but armed in a similar manner. The genital operculum is larger and measures 0·63 mm. wide and 0·48 mm. from base to apex.

Localities: Mount Wellington, Dromedary, Huon, Geeveston, Hastings, Catamaran ,Andover, Woodsdale, Nugent, Eaglehawk Neck and Highcroft. All these places are situated in the south-east quarter of Tasmania.







Triaenobunus pectinatus Pocock.

FIG. 174.—Dorsal view of scutum and free tergites of male.
FIG. 175.—A lobed granule from the scutum.
FIG. 176.—Prolateral view of pedipalpus of male.
FIG. 177—Lateral view of distal part of penis.
FIG. 178.—Leg I of male.

Triaenobunus pectinatus is very common on Mount Wellington. It is more tolerant of dry conditions than are most opilionids and is often found under charred logs on hillsides which become very dry in summer. Adult specimens may be collected throughout the year.

Variations: The collection contains 37 males and 46 females. The males vary in body-length from 3·7-5·3 mm. and the females from 3·19-5·10 mm. The tarsal segmentation in both sexes is normally 3, 6, 4, 4. Only eight out of the 83 specimens in the collection depart from the normal segmentation (see Table 15). All the specimens have four segments in each of tarsi III and IV.

Table 15

Number of specimens	Sex	Number of segments in tarsus II	Number of segments in tarsus I
33	♂	3	6
2	♂	3	7L 6R
1	♂	3L 2R	6
1	♂	3	4L 7R
42	♀	3	6
1	♀	3	4
1	♀	3	6L 5R
1	♀	3	5L 6R
1	♀	3	6L 7R

TRIAENOBUNUS ASPER sp. n.

(Figures 179-185)

Holotype Male

Measurements in millimeters: Body-length 4·00, length of scutum 3·20, length of carapace 1·54.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·97	0·40	1·20	0·63	0·69	1·03	0·54	5·46
Leg 2	1·43	0·63	2·06	1·14	1·37	2·00	1·20	9·83
Leg 3	1·31	0·57	1·14	0·63	0·97	1·26	0·63	6·51
Leg 4	1·71	0·69	1·60	0·69	1·31	2·17	0·86	9·03
Pedipalpi	0·40	0·29	0·80	0·51	0·51	....	0·57	3·08

Colour (in alcohol): Carapace and tergal Areas I, II and V yellow. Tergal Areas III and IV yellow in the middle, dark-brown at the sides. Eyemound, spines, tubercles and free tergites dark-brown. Chelicerae and pedipalpi yellowish with brown reticulations. Legs dark-brown with an indistinct yellowish band on femora, tibiae and metatarsi. Calcaneus of legs I, III and IV white. Ventral surface of body yellowish in the middle merging into brown laterally.

Scutum (fig. 179) armed with a row of about five sharp spines on each side of the anterior margin. The three outermost spines on each side consisting of two large spines with a small one between them. Four small spines near the margin above the base of leg II. Eyemound on anterior margin and extending forward as a three-pronged projection, the middle prong being slightly longer than the lateral prongs. Behind the lateral prong on each side is a small spine and behind the small spine a much larger spine below the eye. Between the eyes the dorsal surface of the eyemound is furnishd with small tubercles. The scutum is decorated with a pattern of lobed granules as shown in fig. 179. The scutal groove is distinct in the middle only. A pair of short median spines is present on each of tergal Areas I-IV and also a small spine on each side in Areas I-III. The free tergites and Area V are each provided with an anterior and a posterior marginal row of lobed granules and between the rows of granules a transverse row of conical spines.

Chelicerae have a small dorsal apical spine on the basal segment and two small dorsal tubercles on the second segment. The length of the basal segment is 0·40 mm. that of the second segment 0·86 mm.

The pedipalpi (fig. 180) are about equal in length to the scutum. The trochanter is armed below with a conical tooth. The femur has a row of three small teeth on the prodorsal surface and two small tubercles near the apex on the retrodorsal side. On the prolateral side there is a small apical tubercle. On the ventral surface a large trifurcate basal tooth and two large teeth on the retromargin. Patella tuberculate above. Tibia tuberculate above and below. Tarsus with three teeth on each side.

Tubercles are present on all coxae. Those on the anterior margin of coxae I and II, those behind the apex of coxa II and in front of the apex of coxa IV larger and more spine-like than the rest. The sternum and genital operculum have the form shown in fig. 181. The genital operculum measures 0·4 mm. wide and 0·4 mm. from base to apex. The penis is illustrated in fig. 182. It closely resembles that of *T. pectinatus* described above. Each sternite has a transverse row of small tubercles which are larger at the sides than in the middle. The respiratory spiracles are concealed.

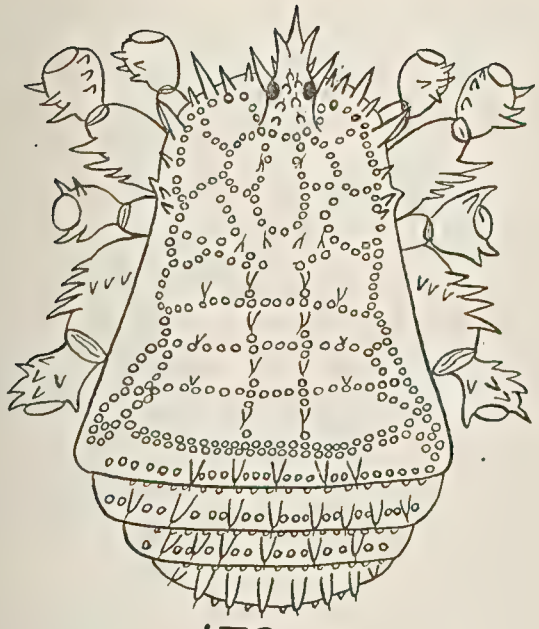
The legs are armed with spinous tubercles on all trochanters, femora, patellae and tibiae. The spines on the femora of legs I and IV are longer than those on other segments. Femur I (fig. 183) has about eight spines in a row on the dorsal surface and about 10 in an irregular double row on the retrolateral side. On the ventral surface there is a proventral row of three large teeth and retroventral row of five. The calcaneus of each metatarsus is small and knob-like (fig. 184). The tarsal segmentation is 3, 6, 3, 3. Distitarsi I and II have two and three segments respectively.

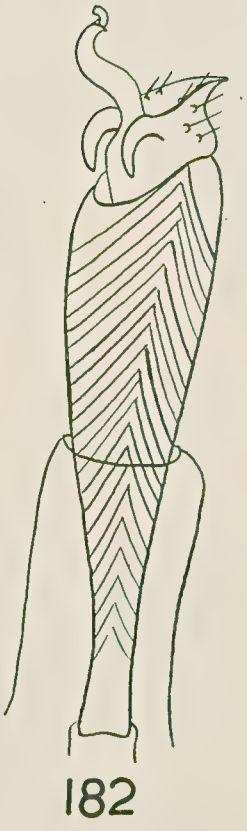
Allotype Female

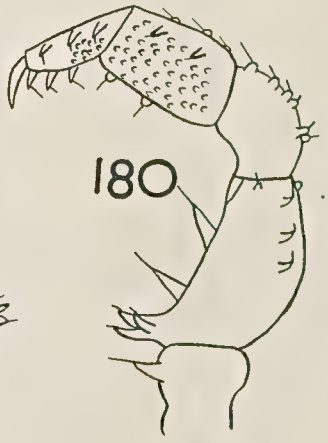
Measurements in millimeters: Body-length 3·94, length of scutum 3·08, length of carapace 1·37.

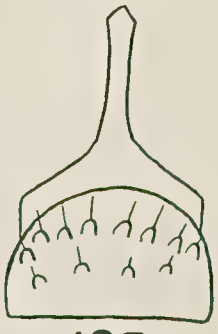
	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·86	0·46	1·09	0·57	0·74	0·91	0·51	5·14
Leg 2	1·31	0·51	1·94	1·20	1·43	1·83	1·20	9·42
Leg 3	1·14	0·46	1·14	0·68	1·03	1·31	0·68	6·44
Leg 4	1·54	0 63	1·60	0·68	1·31	2·06	0·86	8·68
Pedipalp	0·29	0·34	0·69	0·51	0·51	....	0·45	2·79

The female resembles the male in general form. However, the yellow colouration on the scutum is confined to a U-shaped area on the carapace immediately behind the eyemound and an indistinct median region on tergal Areas I, II and III. The pedipalpi are shorter and the trifurcate basal tooth below the femur is much smaller than in the male. The sternum and genital operculum (fig. 185) are wider than those of the male. The operculum measures 0·57 mm. wide and 0·40 mm. long.









Triaenobunus asper sp. n.

FIG. 179.—Dorsal view of scutum and free tergites of male.
FIG. 180.—Prolateral view of pedipalpus of male.
FIG. 181.—Sternum and genital operculum of male.
FIG. 182.—Dorsolateral view of penis.
FIG. 183.—Leg I of male.
FIG. 184.—Metatarsus and tarsus of leg IV of male.
FIG. 185.—Sternum and genital operculum of female.

Localities: The type specimens were collected under decaying logs in a valley on the west of Trevallyn, Launceston, Tasmania, 29th January, 1945. The species also occurs at Gould's Country and St. Mary's Pass.

Variations: The collection contains 24 males and 27 females. The males vary in body-length from 2·78-4·06 mm. and females from 2·90-4·18 mm. The normal tarsal segmentation in both sexes is 3, 6, 3, 3. All specimens have three segments in each of tarsi I, III and IV. Variations in the number of segments in tarsus II are shown in Table 16.

Table 16

Number of specimens	Sex	Number of segments in tarsus I	Number of segments in tarsus II
21	♂	3	6
2	♂	3	6L 7R
1	♂	3	6L 5R
25	♀	3	6
1	♀	3	5L 6R
1	♀	3	7L 6R

TRIAENOBUNUS INORNATUS sp. n.

(Figures 186-188)

Holotype Male

Measurements in millimeters: Body-length 3·31, length of scutum 2·74, length of carapace 1·26.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·86	0·40	1·54	0·80	0·91	1·49	0·34	6·34
Leg 2	1·31	0·51	2·63	0·91	2·28	2·63	0·86	11·13
Leg 3	1·26	0·40	1·66	0·80	1·43	2·00	0·45	8·00
Leg 4	1·77	0·63	2·28	0·97	1·94	2·80	0·62	11·01
Pedipalp	0·40	0·34	1·43	1·03	1·14	....	1·03	5·37

Colour (in alcohol): Scutum yellowish with an elongate dark area on each side extending through the posterior three-quarters and ending in the posterior lateral corners. Indistinct dark marks in the middle of the tergal Areas. Free tergites yellowish with faint dark marks. Chelicerae, pedipalpi and legs yellowish. Femora of legs darker in basal half. Sternites yellowish-brown merging into dark-brown laterally and with a pair of dark-brown patches in the middle.

Scutum (fig. 186) depressed and armed on the front margin at each side with a row of about eight tubercles, the five outer ones being short and blunt, the three inner ones being longer, slightly curved and spine-like. The eyemound arises from the front margin and extends forward horizontally in the form of a trident, the two lateral prongs of which bend inwards towards the median prong, which is curved slightly downwards. Behind the lateral prongs and situated below the eyes is a pair of large sharp spines directed forwards and outwards. The surface of the scutum is clothed with coarse granules, which, however, do not form a pattern. The scutal groove is distinct in the middle. Other grooves are not evident. Tergal Area V has a transverse row of spinous tubercles, of which the three median ones are the largest. Each free tergite has a transverse anterior row of small blunt tubercles and a posterior row of large spinous tubercles. The third free tergite is hidden below the second. Anal operculum granular.

Chelicerae granular and unarmed. Pedipalpi (figs. 187) granular and about twice the length of the scutum. Trochanter armed below with about five small tubercles. Femur with a prodorsal row of about 11 spinous tubercles which are directed inwards and three small tubercles at the apex. On the prolateral side a row of four tubercles in the distal half and one at the apex. On the ventral surface a large bifid basal tooth which is directed inwards, four small promarginal teeth and three large retromarginal teeth with a small one between the first and second. Patella tuberculate dorsally and with three small prolateral teeth and one small retroventral tooth. Tibia tuberculate above and below and with an irregular row of six or seven teeth on each side. Tarsus tuberculate above and below and with five teeth on each side.

Coxae granular and provided with a marginal row of tubercles in front and behind. Those in front of coxae I and II being larger and more spine-like than the others. Sternites granular and furnished with a transverse row of small tubercles which increase in size laterally. Genital operculum measures 0·51 mm. wide and 0·40 mm. from base to apex. The surface of the operculum is tuberculate. Respiratory spiracles concealed.

Legs long and slender, armed with spinous tubercles on the trochanters, femora, patellae and tibiae. The tubercles on the femora are larger than those on other segments. Leg 1 (fig. 188) is more strongly armed than the other legs. The trochanter has a promarginal and a retromarginal tubercle above and a group of about six tubercles below. The femur has a dorsal row of about nine teeth and a ventral row of about eight, the two proximal teeth in the ventral row being the largest. The tibia has two conspicuous tubercles on the ventral surface, one near the base, the other near the middle of the segment. Calcaneus of each metatarsus short and knob-like. Tarsal segmentation 2, 4, 4, 4. Distitarsi I and II with one and three segments respectively.

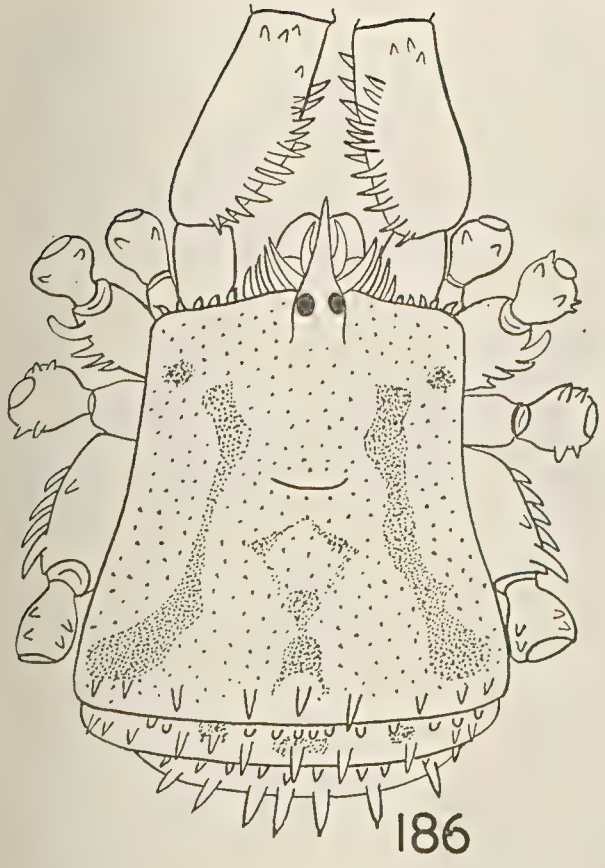
Allotype Female

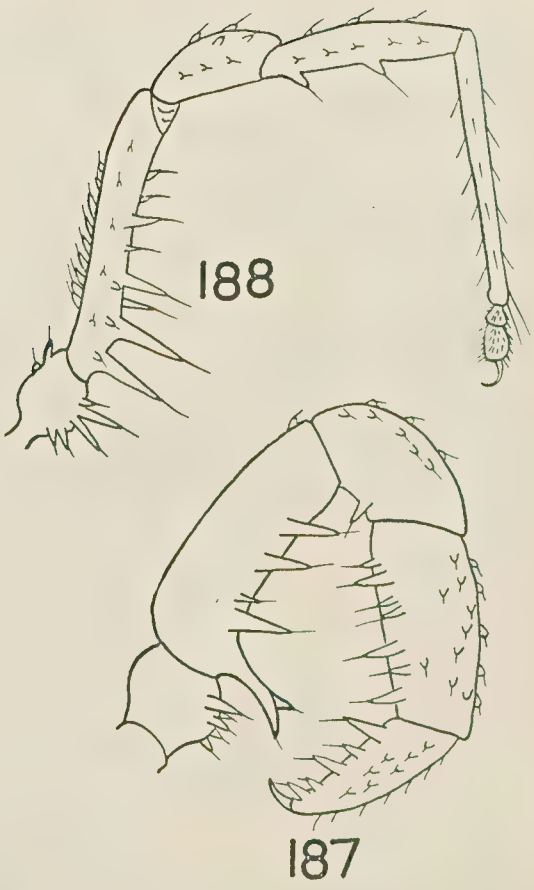
Measurements in millimeters: Body-length 3·60, length of scutum 2·85, length of carapace 1·43.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·80	0·51	1·71	0·86	1·26	1·60	0·40	7·14
Leg 2	1·43	0·57	3·43	1·14	3·03	3·43	0·86	13·89
Leg 3	1·26	0·51	2·23	0·86	1·71	2·34	0·57	9·48
Leg 4	1·71	0·63	2·86	1·14	2·28	3·54	0·63	12·79
Pedipalp	0·45	0·40	1·60	0·91	1·21	....	1·14	5·70

The female resembles the male in general appearance. However, the bifid basal tooth on the ventral surface of the femur of the pedipalpus is shorter in the female. The spines forming a row across tergal Area V are much smaller and less spine-like than those of the male. Both sexes have the same tarsal formula.

Locality: The holotype male was collected under a log near Lake Fenton, National Park, Tasmania, 27th March, 1932. The allotype female was found under a log near the Lyell Highway about two miles on the western side of King William Saddle, 23rd May, 1954. Only one other specimen is in the collection before me. It was found near Wilmot.





Triaenobunus ornatus sp. n.

FIG. 186.—Dorsal view of scutum and free tergites of male.
FIG. 187.—Retrolateral view of pedipalpus of male.

FIG. 188.—Leg I of male.

TRIAENOBUNUS PILOSUS sp. n.

(Figures 189-192)

Holotype Female

Measurements in millimeters: Body-length 3·14, length of scutum 2·74, length of carapace 1·20.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·74	0·40	1·66	0·86	1·14	1·37	0·40	6·57
Leg 2	1·20	0·54	3·14	1·20	2·68	2·40	0·97	12·13
Leg 3	1·14	0·51	1·88	0·80	1·54	1·88	0·46	8·21
Leg 4	1·60	0·57	2·46	1·08	2·11	2·86	0·57	11·25
Pedipalp	0·51	0·34	1·14	0·86	0·86	....	0·74	4·45

Colour (in alcohol): Scutum pale-cream, almost white, with a dark-brown area on each side of the anterior half. Faint transverse bars on tergal Areas II, III and IV. Tergites pale-cream. Chelicerae, pedipalpi and legs also pale-cream. Ventral surface of body pale-cream except the fused eighth and ninth sternites which are dark-brown.

Scutum (fig. 189) somewhat depressed. Scutal groove distinct in the middle. A small indentation is present on each side at the level of the scutal groove. Anterior margin with about seven tubercles on each side. Each tubercle is elongate and somewhat cylindrical. Its surface is clothed with short hairs. All tubercles and spines on the body and appendages are pilose. Eyemound small, conical and extending forwards over the front margin in the form of a short trident. The lateral prongs of the trident bend inwards towards the median prong which curves slightly downwards. The three prongs are clothed with short hairs. Below and slightly behind the eye two large spines project outwards and forwards from the base of the eyemound. The surface of the scutum is decorated with a pattern of small pilose erect tubercles, which have the form shown in fig. 190. The tubercles vary in size but most of the ones forming the pattern are about 0·129 mm. high and 0·048 mm. in diameter. Tergal grooves are indistinct but the pattern of tubercles indicates the position of the tergal Areas. The free tergites and tergal Area V each have a transverse row of elongate pilose tubercles. The third free tergite is hidden below the second. The anal operculum is devoid of tubercles.

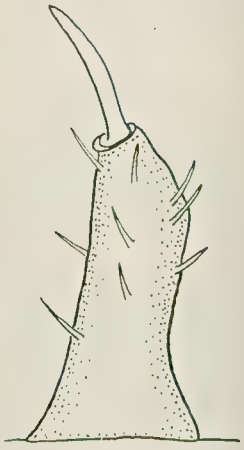
Chelicerae small and unarmed. Pedipalpi (fig. 191) rather slender and longer than the body. The trochanter is furnished with two tubercles below. The femur has a dorsal row of about 10 tubercles and a prolateral row of three in the distal half. On the ventral surface there is a large simple basal tooth, a retromarginal row of four and a promarginal row of three teeth. Patella tuberculate above and with two prolateral tubercles. Tibia tuberculate above and provided with about nine tubercles on the retrolateral side and seven on the prolateral side. The tarsus has three teeth on each side.

All coxae tuberculate. The tubercles form a group below coxa I and a promarginal row on coxae II, III and IV. Behind the apex of coxa II there are two tubercles, the distal one being large, curved and blunt. In front of the apex of coxa IV there are four or five tubercles, the distal one being the largest. The genital operculum is tuberculate and there is a row of very small tubercles on each sternite. The respiratory spiracles are concealed.

The legs are long and slender. Tubercles are present on the trochanters, femora, patellae and tibiae. Those on the femora are larger than the ones on other segments. Leg I (fig. 192) is more strongly armed than the other legs. The femur has a dorsal row of about seven elongate tubercles, a retrolateral row of six, a proventral row of four and a retroventral row of five. The calcaneus is feebly developed and scarcely to be distinguished on any of the metatarsi. The tarsal segmentation is 3, 5, 4, 4. Distitarsi I and II have two and three segments respectively.

Locality: The holotype female was found under a decaying log in the Fern Glade near the Emu River, Burnie, 24th August, 1954. A male specimen was found at Wilmot in December, 1927, and another at Hellyer Gorge in August, 1954.

Unfortunately the male specimens are damaged and not suitable for description. However, one of them, less damaged than the other, has a tarsal formula 3, 4, 4, 4 and its pedipalpi are larger and stronger than those of the female.



Triaenobunus pilosus sp. n.

FIG. 189.—Dorsal view of scutum and free tergites of female.
FIG. 190.—A conical tubercle from scutum.
FIG. 191.—Retrolateral view of pedipalpus of female.
FIG. 192.—Leg I of female.

TRIAENOBUNUS MESTONI sp. n.

(Figures 193-195)

Holotype Male

Measurements in millimeters: Body-length 3·31, length of scutum 2·40, length of carapace 1·14.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·80	0·34	1·14	0·62	0·80	1·03	0·34	5·07
Leg 2	1·20	0·40	2·00	0·86	1·48	1·77	0·86	8·57
Leg 3	1·14	0·40	1·14	0 63	0·97	1·26	0·34	5·88
Leg 4	1·43	0·57	1·71	0·86	1·43	2·00	0·46	8·46
Pedi-palp	0·40	0·34	1·14	0·74	0·69	....	0·63	3·94

Colour (in alcohol): Scutum brownish-yellow with a dark-brown longitudinal area on each side in the posterior three-quarters. Between the dark-brown longitudinal areas is an elongated dark-brown shield-shaped patch covering the median region of the tergal Areas I-V, and marked with indistinct yellow bars or spots on each of the Areas I-III. The eyemound dark-brown above with dark reticulations behind. Free tergites yellowish. Chelicerae and pedipalpi yellow with dark-brown reticulations. Tarsi of pedipalpi pale distally. Legs brown with pale trochanters and tarsi. Ventral surface of body dark-brown with coxae I and II yellow and a median yellow band extending from mouth to anus. Sternites brownish on either side of the yellow band.

Scutum (fig. 193) depressed. Scutal groove distinct in the middle. Tergal grooves indistinct. Anterior margin armed on each side with a row of six spines, the four outer ones being shorter than the two inner ones. Eyemound arising from the front margin and bent forward in the form of a horizontal trident. The median prong of the trident is curved slightly downwards and the two lateral prongs, which arise from the sides of the eyemound, are curved slightly inwards towards the median prong. Close behind the lateral prongs and below and slightly in front of the eyes is a pair of long sharp spines, which project forwards and outwards. The surface of the scutum is decorated with an open pattern of lobed granules, a double row of which extends forwards from the scutal groove onto the post-ocular region of the eyemound. On each side of the scutum granules extend forward to the base of the eyemound but do not reach the front margin. On each of the tergal Areas I-IV is a median pair of very small spinous tubercles. On Area V and each free tergite is a transverses row of tubercles preceded by a transverse row of lobed granules. The tubercles on Area V are very small being little larger than the lobed granules, but those on the free tergites, especially on the second, are very large. The third free tergite is generally concealed by the preceding one.

Chelicerae small and unarmed . Pedipalpi (fig. 194) slightly longer than body. Trochanter with one proventral and two retroventral teeth. Femur with a dorsal row of about 10 teeth which are directed inwards, a prolateral row of four in the distal half, a ventral bifid basal tooth directed inwards, a proventral row of four small teeth and a retroventral row of three large teeth. The patella tuberculate above and armed with a small retrolateral and two larger prolateral tubercles. Tibia tuberculate above and below with about six small teeth on each side. Tarsus with six teeth on each side, the first and fourth being larger than the others. Tarsal claw short.

Coxae with an anterior and a posterior marginal row of tubercles, those in front of coxae I and II being much larger than the others. There are two tubercles behind the apex of coxa II, the distal one being large, curved and blunt. Three large and several smaller tubercles are situated in front of the apex of coxa IV. Genital operculum tuberculate. Each sternite has a transverse row of small tubercles, which increase in size laterally.

Legs have small conical tubercles or granules on trochanters, femora, patellae and tibiae, except in the case of leg I (fig. 195) which is more strongly armed. The trochanter of leg I has a ventral row of four or five strong teeth. The femur has a dorsal row of about nine teeth, a retroventral double row of about 10 conical tubercles and a ventral row of seven teeth. of which the first, second and fourth are larger than the others. The left tibia has two conspicuous ventral tubercles, one near the base and the other near the middle. The right tibia has a third smaller tubercle in the distal half of the ventral surface. The calcaneus of each metatarsus is small and knob-like. The tarsal segmentation: 2, 4, 3, 3. Tarsus II of the left side is abnormal and has only two segments.

Allotype Female

Measurements in millimeters: Body-length 2·85, length of scutum 2·06, length of carapace 0·97.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·57	0·32	0·97	0·57	0·74	0·91	0·29	4·37
Leg 2	1·03	0·46	1·71	0 80	1·54	1·60	0·74	7·88
Leg 3	0·86	0·29	0·91	0·62	0·97	1·14	0·34	5·13
Leg 4	1·37	0·57	1·49	0·68	1·26	1·71	0·46	7·54
Pedi-palp	0·34	·0·34	0·91	0·57	0·57	....	0·57	3·30

The female resembles the male in general appearance but is slightly smaller. The dark-brown areas on the scutum are more extensive than in the male. The pedipalpi are shorter and the basiventral tooth of the femur is much smaller and not bifid. The genital operculum measures 0·57 mm. wide and 0·34 mm. from base to apex. It is larger than in the male.

Locality: The holotype and allotype were found under a decaying log near Highcroft, Tasman Peninsula, Tasmania, 23rd February, 1940. They were collected by A. L. Meston.

Triaenobunus mestoni sp. n.

FIG. 193.—Dorsal view of scutum and free tergites of male.
FIG. 194. Retrolateral view of pedipalpus of male.
FIG. 175.—Leg I of male.

TRIAENOBUNUS MONTANUS sp. n.

(Figures 196-198)

Holotype Female

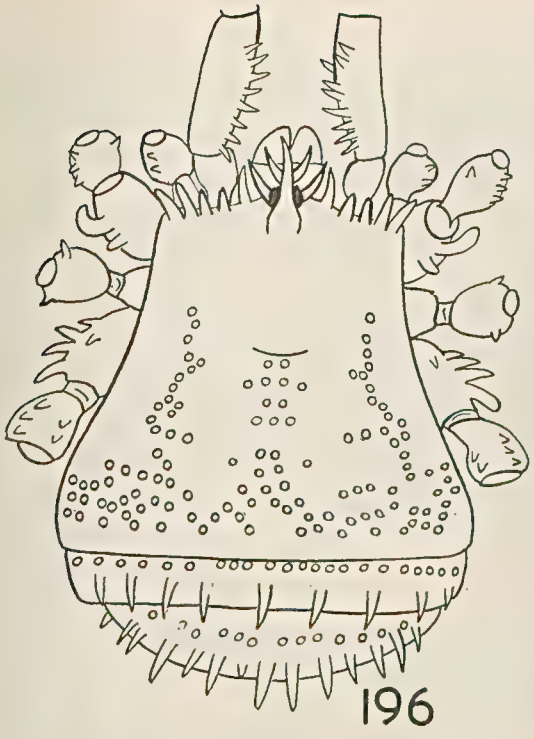
Measurements in millimeters: Body-length 3·26, length of scutum 2·34, length of carapace 1·08.

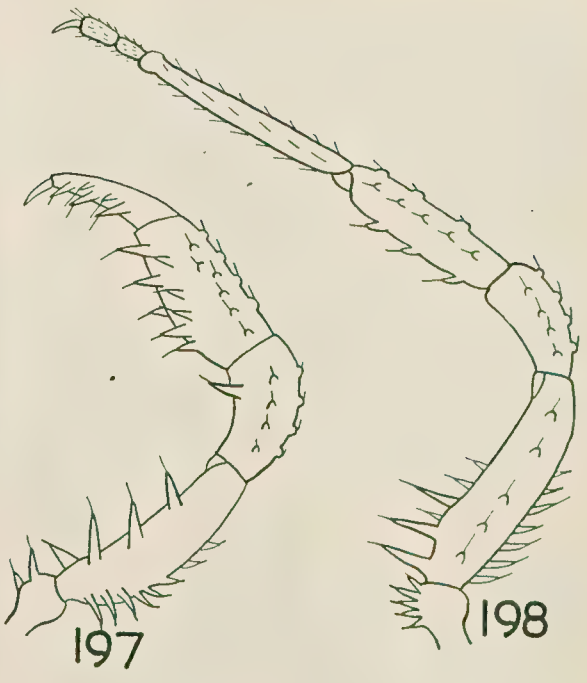
	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·74	0·40	1·14	0·68	0·86	1·09	0·34	5·25
Leg 2	1·06	0·46	2·00	1·03	1·77	1·82	0·86	9·00
Leg 3	1·14	0·46	1·26	0·68	1·08	1·37	0·46	6·45
Leg 4	1·54	0·63	1·71	0·86	1·14	2·11	0·46	8·45
Pedipalp	0·40	0·34	0·97	0·69	0·69	....	0·69	3·78

Colour (in alcohol): Scutum anteriorly yellowish marked with dark-brown reticulations on either side of and behind the eyemound. Posterior two-thirds of the scutum mainly dark-brown, the tergal Areas I-IV being marked with a pair of yellowish spots or short transverse bars in the median region. Free tergites yellowish-brown. Chelicerae yellowish with brown reticulations. Pedipalpi and legs brown, except the tarsi, trochanters and distal part of the coxae which are paler. Ventral surface of body brown except for a median yellow band extending from the mouth to the posterior margin of the seventh sternite, and the coxae which are yellowish with dark-brown reticulations on the last three pairs.

Scutum depressed. Scutal groove distinct in the middle. Tergal grooves indistinct. Anterior margin armed on each side with a row of six tubercles, the third and fourth on each side being shorter and blunter than the others. Eyemound conical and bent forward over the anterior margin in the form of a trident, the median prong of which is bent slightly downwards. The lateral prongs curve slightly towards the median prong. Behind the lateral prongs and arising below the eyes is a pair of long spines which project forwards and outwards. The surface of the scutum is decorated with a pattern of lobed granules (fig. 196). The pattern is open in front and, on each side, does not extend far in front of the level of the scutal groove. No tubercles or granules are present on the eyemound or between the eyemound and scutal groove. Each free tergite has a transverse row of large spinous tubercles, immediately in front of which is a transverse row of lobed granules. The third free tergite is hidden below the second.

Chelicerae small and unarmed. Pedipalpi (fig. 197) with two spines below the trochanter. The femur has a dorsal row of about 10 spines which





Triaenobunus montanus sp. n.

FIG. 196.—Dorsal view of scutum and free tergites of female.
FIG. 197.—Prolateral view of pedipalpus of female.
FIG. 198.—Leg I of female.

are directed inwards, a prolateral row of four in the distal half, a simple non-bifid basiventral tooth, three large retroventral teeth and four small proventral teeth. Patella tuberculate above and armed with two large proventral teeth and one small retroventral tooth near the apex. Tibia tuberculate above and below, armed on each side of the ventral margin with about five teeth, above which is a second row of three smaller teeth. Tarsus tuberculate above and armed with about five teeth on each side.

Coxae provided with a marginal row of tubercles in front and behind. Those on the front margin of coxae I and II being much larger than the others. Behind the apex of coxa II are two tubercles, the distal one being large, blunt and curved. In front of the apex of coxa IV there are about five tubercles, the two distal ones being blunt and curved. The genital operculum is tuberculate. Each sternite has a transverse row of small tubercles, which increase in size laterally. Respiratory spiracle concealed.

Trochanter of leg I (fig. 198) with five ventral teeth. The femur has a dorsal row of about 10 teeth and a ventral row of six. The first, second and fourth in the ventral row are much larger than the others. The tibia has a ventral row of three conspicuous tubercles. Legs II-IV are weakly armed with small tubercles on the trochanters, femora, patellae and tibiae. The calcaneus is poorly differentiated on all the metatarsi. Tarsal segmentation: 2, 4, 3, 3.

Locality: The holotype female was found under a decaying log in the Myrtle Forest, Collinsvale, Tasmania, 8th November, 1955. The collection contains two other female specimens, one from Mount Wellington, the other from the Arve Forest at Geeveston.

TRIAENOBUNUS CORNUTUS sp. n.

(Figures 199-201)

Holotype Male

Measurements in millimeters: Body-length 4·28, length of scutum 3·14, length of carapace 1·43.

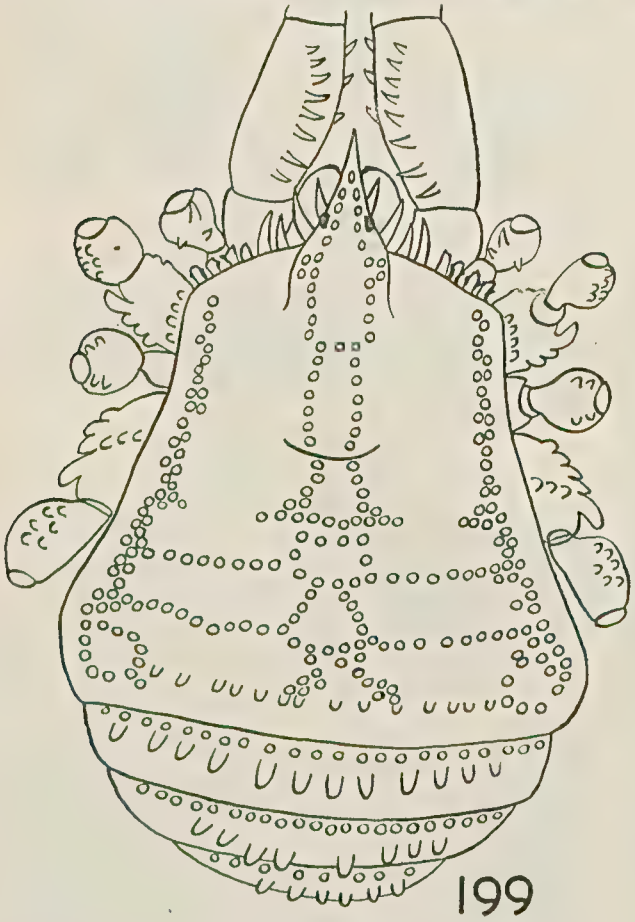
	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·97	0·34	1·14	0·57	0·86	0·97	0·46	5·31
Leg 2	1·43	0·46	2·17	0·80	1·71	2·06	1·03	9·66
Leg 3	1·14	0·40	1·37	0·57	1·14	1·71	0·46	6·79
Leg 4	1·71	0·51	1·94	0·86	1·60	2·68	0·57	9·87
Pedipalp	0·46	0·40	1·26	1·03	0·86	....	0·69	4·70

Colour (in alcohol): Scutum yellowish-brown with dark reticulations at the sides of the carapace. Tergal region dark-brown at the sides and with a median dark-brown V-shaped mark on tergal Areas II-IV; that on Area IV being continued posteriorly onto Area V. Free tergites mainly dark-brown. Chelicerae and pedipalpi mainly brownish-yellow. Legs brown with two dark bands on femora, tibiae and metatarsi. Coxae yellowish-brown. Sternum dark-brown. Genital operculum yellow in the middle, brown laterally. Sternites

dark-brown with a pair of longitudinal yellowish stripes converging posteriorly.

Scutum (fig. 199) convex from side to side. Anterior margin on each side of the eyemound is oblique and armed with a row of six tubercles, of which the four outer ones are short, blunt and irregular, the two inner ones sharp and spine-like. The eyemound large, conical and arising from the front margin. It projects forwards and upwards in the form of a trident, the median prong of which is much longer than the lateral prongs. The latter arise below the base of the median prong and in front of the eyes. They are little more than half the length of the median prong. Behind the lateral prongs and below the eyes another pair of large spines project forwards and outwards. The scutal groove is distinct medianly. The tergal grooves indistinct. The surface of the scutum is decorated with an open pattern of lobed granules arranged as shown in fig. 199. A median double row of granules extends from the scutal groove onto the dorsal surface of the eyemound and is continued forward between the eyes onto the median prong of the trident. Here the two rows converge into a single row of small tubercles leading almost to the distal end of the prong. Each free tergite has a transverse row of short blunt conical tubercles preceded by a transverse row of lobed granules.

Chelicerae unarmed; the basal segment measures 0·68 mm. long and the second segment 1·20 mm. Pedipalpi (fig. 200) are slightly longer than the body. The trochanter is provided with three ventral tubercles. The femur has a dorsal row of about eight teeth, a prolateral row of three in the distal half, a large basiventral tooth which is bifid and directed inwards, two large retroventral teeth with a smaller one between them, and three small proventral teeth. The patella and tibia are tuberculate on the dorsal surface. The patella has two prolateral and one small retrolateral tubercle. The tibia is armed with about five small teeth on each side and the tarsus with three on each side.



Triaenobunus cornutus sp. n.

Fig. 199.—Dorsal view of scutum and free tergites of male.
Fig. 200.—Retrolateral view of pedipalpus of male.
Fig. 201.—Leg I of male.

Coxae are each provided with a marginal row of small tubercles or granules in front and behind. Those on the front of coxa I being larger and more spine-like than the others. The tubercles behind the apex of coxa II and in front of the apex of coxa IV are small and blunt. Genital operculum with a few tubercles towards the front. Sternum wide posteriorly. Sternites each with a transverse row of small granules. Respiratory spiracle concealed.

Leg I (fig. 201) has two marginal tubercles on each side of the dorsal surface of the trochanter and a group of six tubercles on the ventral surface. The femur is armed above with a row of seven uniform teeth and below with eight, the first three of which are much larger than the others. The tibia has two large tubercles on the ventral surface, one near the base, the other near the middle. Legs II-IV are unarmed except for a few small tubercles mainly on the femora. The calcaneus of each metatarsus is small and knob-like. Tarsal segmentation: 2, 4, 3, 4. Distitarsi I and II with one and two segments respectively.

Allotype Female

Measurements in millimeters: Body-length 3·71, length of scutum 2·97, length of carapace 1·20.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·69	0·40	1·14	0·63	0·86	0·91	0·40	5·03
Leg 2	1·26	0·46	2·06	0·80	1·71	2·06	0·97	9·32
Leg 3	1·09	0·40	1·43	0·68	1·14	1·65	0·46	6·85
Leg 4	1·37	0·57	1·94	0·86	1·60	2·57	0·57	9·48
Pedipalp	0·45	0·46	1·20	0·97	0·80	....	0·57	4·45

The female resembles the male in general appearance but is slightly smaller. The pedipalpi are shorter and less robust. The bifid basiventral tooth on the femur of the pedipalpus is much smaller. The tarsal segmentation is the same in both sexes.

Locality: The holotype male and allotype female were found under fallen logs in a valley north of the Cataract Gorge, Trevallyn, Tasmania, August, 1931.

Genus **GLYPTOBUNUS** Roewer, 1914

This genus was founded by Roewer (1914, p. 161) on the characters of a single male specimen of *Glyptobunus signatus* from Tasmania. In the definition of the genus tarsus I is said to have three segments. Whilst this is true in many cases, it is not true in all. The collection before me contains over 170 specimens of the harvestman and a large number of the males have four segments in tarsus I. The feature is therefore variable. The definition of the genus is accordingly amended to read as follows.

Eyemound set back from anterior margin by a distance equal to about one half of its basal diameter and surmounted by a median spine. Carapace ornamented with a pattern of lobed granules. The anterior margin furnished above with a row of small tubercles. Transverse furrows of scutum distinctly marked and provided with lobed granules. Tergal Areas each with a transverse row of tubercles. The median tubercles on Area IV are larger and more widely spaced than those on Areas I-III. Area V and the free tergites each with a transverse row of small tubercles. Tarsus I with three to four segments, tarsus II, 7-12, tarsi III and IV four each. Distitarsi I and II with two and three segments respectively. Claws of legs III and IV three-pronged, the median prong longer and stronger than the lateral prongs.

Genotype: *Glyptobunus signatus* Roewer.

Type Locality: Tasmania.

GLYPTOBUNUS SIGNATUS Roewer

(Figures 202-207)

Male

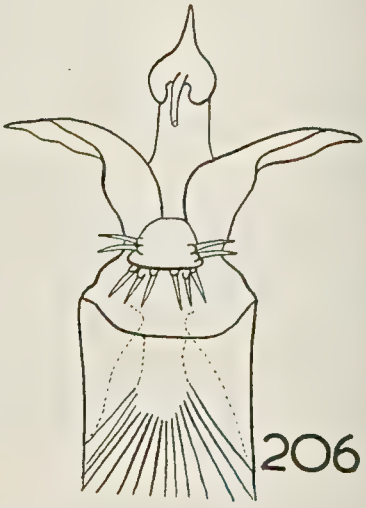
Measurements in millimeters: Body-length 3·14, length of carapace 1·25, length of scutum 2·62.

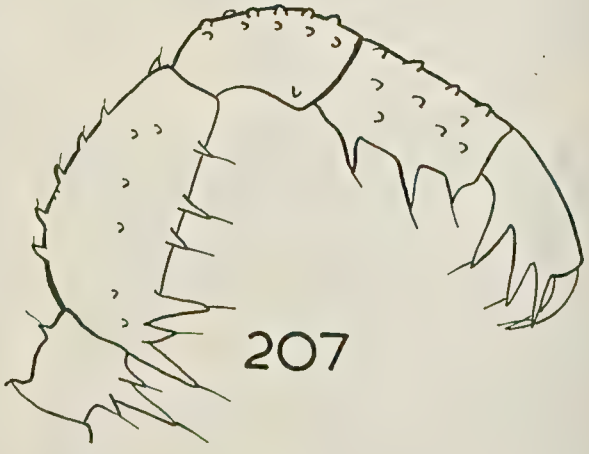
	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·91	0·46	1·54	0·63	1·14	1·66	0·80	7·14
Leg 2	1·19	0·51	2·40	0·79	1·94	2·85	1·77	11·45
Leg 3	1·08	0·46	1·71	0·74	1·43	2·11	0·91	8·44
Leg 4	1·26	0·62	2·28	0·80	1·71	3·25	1·20	11·12
Pedipalp	0·51	0·46	1·60	0·91	0·97	....	0·91	5·36

Colour (in alcohol): Dorsal surface of body dark-brown with a V-shaped yellowish brown region behind eyemound and a pair of yellowish-brown patches on each of tergal Areas I-III. Coxae and trochanters yellow, other leg segments brown. Pedipalpi with dark-brown reticulations on a yellowish-brown ground colour. Genital operculum yellow. Free sternites brown. Anal region yellow.

Frontal margin of carapace provided on each side with a row of about five small spinous tubercles (fig. 202). Immediately behind the row of tubercles is a transverse groove. Eyemound about half its basal diameter from the front margin, slightly constricted below the eyes and provided with a short apical spine (fig. 203). A few small granules are present on the eyemound both above and below the eyes. The surface of the carapace is ornamented with a pattern of lobed granules as shown in fig. 202. Scutal and tergal grooves strongly marked. The first four grooves are furnished with a double row of lobed granules; the fifth groove with a single row. On each side of the scutum the transverse rows of granules unite with a longitudinal row of granules. The lateral margins of the scute are smooth. In each of tergal Areas I-IV there is a transverse row of tubercles, the median pair of tubercles in Area IV being larger and more widely spaced than those in the other Areas. However, in different specimens considerable variation in the size of the median tubercles occurs. In some cases they are much higher and more conical than in others. Area V and each free tergite has a transverse row of tubercles. Each free tergite also has a transverse row of very small rounded granules close to the anterior margin. These are frequently hidden by the posterior edge of the tergite in front.

Chelicerae with a dorsal spine on the inner side at the apex of the basal segment. The second segment has a small spine on the inner side near the base, a larger spine near the middle of the frontal (dorsal) surface, and a few small rounded tubercles (fig. 204).





Glyptobunus signatus Roewer.

FIG. 202.—Dorsal view of scutum and free tergites of male.
FIG. 203.—Lateral view of eyemound.
FIG. 204.—Retrolateral view of chelicera.
FIG. 205.—Retrolateral view of pedipalpus of male.
FIG. 206.—Ventral view of distal parts of penis.
FIG. 207.—Retrolateral view of pedipalpus of female (drawn to a larger scale than FIG. 205).

Pedipalpi (fig. 205) strong and longer than the body. The trochanter has a small dorsal spine and a large ventral spine. On the retrolateral side of the ventral spine are two smaller spines. Femur somewhat swollen; armed with a median dorsal row of about eight small teeth. On each side of the median dorsal row are a few small tubercles. Ventral surface with a large basal spine and a retromarginal row of five spines, of which the second is the largest. The promargin has a row of six small spines. The prolateral surface has two large spines in the distal half. The retrolateral surface is provided with a few small tubercles. The patella is tuberculate above and has two prolateral spines. Tibia tuberculate above and armed with three spines on each side, the middle spine being the largest. Tarsus armed with three spines on each side. Tarsal claw is about three-quarters the length of the tarsus.

Coxa I has a promarginal row of three spines and a few granular spines on the ventral surface. Coxa II has four short spines behind the apex and a transverse row of four small tubercles above the apex and close to the scutal margin. Coxa III with a marginal row of granules in front and behind. Coxa IV with a few short spines in front near the apex and a marginal row of small granules behind.

Genital operculum rounded in front. Surface finely granular and clothed with a few fine hairs. The penis has the form shown in fig. 206. The ventral plate is provided with two pairs of superior setae and three pairs of inferior setae. The glans ends in a sharp point. Posterior to the point the male duct terminates in a narrow tube, which curves downward and backward between two small concave plates. On either side of the base of the glans a large pointed curved lateral process extends outwards and upwards, the two processes appearing like a pair of narrow wings, when viewed from the ventral side.

The respiratory spiracles are concealed under granules on the posterior margin of coxae IV.

Legs with all segments except metatarsi and tarsi coarsely granulate but unarmed. Calcanei short and conical. Segmentation of both tarsus I and II variable. Tarsus I has three to four segments and tarsus II 7-12 . Tarsi III and IV each have four segments. Distitarsi I and II have two and three segments respectively.

Allotype Female

Measurements in millimeters: Body-length 4·11, length of carapace 1·20, length of scutum 2·90.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·68	0·40	1·43	0·65	1·14	1·54	0·86	6·70
Leg 2	1·26	0·46	2·28	0·74	2·11	2·63	1·77	11·25
Leg 3	1·08	0·45	1·43	0·69	1·43	2·00	0·97	8·05
Leg 4	1·31	0·57	2·11	0·80	1·77	3·14	1·25	10·95
Pedipalp	0·45	0·46	1·26	0·86	0·80	....	0·86	4·69

The female resembles the male in colour and general features. The pedipalpi (fig. 207) are not as strong as those of the male, the femur being much smaller in dorso-ventral diameter and not swollen.

Localities: The male and allotype female described above were collected at Tarraleah, Tasmania, 2nd January, 1953. The species is widely distributed in the State, especially in the north, east and centre. It is not often found in the south. The collection contains specimens from Hellyer Gorge, Table Cape, Western Creek, Liffey Falls, Trevallyn, Scottsdale, Gould's Country, Andover, Parattah, Swanston, Woodsdale, Lake St. Clair, Great Lake region, Butler's Gorge, National Park, and Eaglehawk Neck. The species occurs under decaying logs.

Variations: Adult males vary in body-length from 2·49-3·77 mm. and adult females from 3·02-4·64 mm. The number of spines on the anterior margin of the carapace is usually five on each side but sometimes six. The eyemound varies in height and in granulation. The tubercles on the tergal Areas vary in number and size. As already mentioned the number of segments in tarsus I is either three or four and some asymmetric specimens have three on the left and four on the right side. The segmentation of tarsus II varies from 7-12, and considerable asymmetry is exhibited. Tarsi III and IV each have four segments and this number appears to be constant. Table 17 shows the segmentation of tarsi I and II in 85 males and 88 females.

Table 17

Number of specimens	Sex	Number of segments in tarsus I	Number of segments in tarsus II
2	♂	3	8
1	♂	3	8L 9R
10	♂	3	9
3	♂	3	9L 8R
8	♂	3	9L 10R
13	♂	3	10
10	♂	3	10L 9R
2	♂	3	11
1	♂	3	11L 10R
1	♂	3L 4R	8
1	♂	3L 4R	9L 10R
1	♂	3L 4R	10L 9R
2	♂	4	8
1	♂	4	8L 7R
6	♂	4	8L 9R
5	♂	4	9
1	♂	4	9L 8R
5	♂	4	9L 10R
1	♂	4	9L 11R
4	♂	4	10
1	♂	4	10L 8R
1	♂	4	10L 9R
1	♂	4	10L 11R
1	♂	4	11L 10R
1	♂	4	11L 12R
1	♂	4L 3R	11L 10R
1	♂	4L 3R	11
2	♀	3	7
3	♀	3	7L 8R
1	♀	3	7L 9R
3	♀	3	8L 7R
18	♀	3	8
11	♀	3	8L 9R
1	♀	3	8L 10R
1	♀	3	9L 6R

Table 17—(*continued*)

Number of specimens	Sex	Number of segments in tarsus I	Number of segments in tarsus II
11	♀	3	9L 8R
24	♀	3	9
5	♀	3	9L 10R
3	♀	3	10L 8R
4	♀	3	10L 9R
1	♀	4L 3R	9

Specimens of *Glyptobunus signatus* occurring in regions on the eastern side of Tasmania tend to have a longer spine on the eyemound and more spine-like tubercles on the tergal Areas and free tergites than do those found on the western side of the State and on the central plateau.

GLYPTOBUNUS ORNATUS sp. n.

Holotype Male

Measurements in millimeters: Body-length 4·57, length of carapace 1·83, length of scutum 4·05.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	1·20	0·63	2·91	1·14	2·00	2·91	0·86	11·65
Leg 2	1·77	0·69	4·74	1·26	4·23	5·94	2·11	20·74
Leg 3	1·77	0·74	3·60	1·26	2·85	4·68	1·26	16·16
Leg 4	2·06	0·80	4·45	1·31	3·43	6·63	1·43	20·11
Pedipalp	0·91	0·86	2·86	2·11	2·00	....	1·88	10·62

Colour (in alcohol): Dorsal surface of body dark-brown with a golden-yellow band situated on each side of the eyemound and extending from the anterior margin to the posterior edge of tergal Area IV. Behind the eyemound the two yellow bands unite together, but leave small patches of brown between them in a median line on the carapace and tergal Areas. Eyemound dark-brown, with dark-brown reticulations in front. Chelicerae and pedipalpi with dark-brown reticulations and with yellowish joints between the segments. The large spines on the pedipalpi are mainly white. Legs dark-brown with yellowish joints between trochanter and femur, and femur and patella. Ventral surface of body with brown reticulations on a yellowish ground colour.

Carapace with a row of three or four small blunt tubercles above anterior margin on each side. Eyemound erect, conical, situated about half its basal diameter from the front margin, and surmounted by a short spine (fig. 209). Surface of scutum decorated with a pattern of lobed granules (fig. 208). The granules form a border close to the anterior and lateral margins and also mark the transverse grooves. The first and fifth grooves extend laterally almost to the margin, the other grooves do not reach as far to the side. The granules bounding the grooves likewise reach the marginal granules only in the case of the first and fifth grooves. Tergal Areas I-IV are each provided with a median pair of tubercles, those on Areas I and IV being more widely separated than those on Areas II and III. The tubercles on Area IV are larger than the others. Area V and each free tergite are furnished with a transverse row of smaller conical tubercles. The free tergites also possess a transverse row of rounded granules in front of the row of tubercles.

Chelicerae (fig. 210) moderately strong. The basal segment with a large dorsal spine situated on the inner side at the apex and directed forward. The second segment with a small tooth on the dorsal surface near the base and a larger tooth near the middle. A few smaller tubercles are also present on the dorsal surface.

Pedipalpi (fig. 211) strong and armed with very long whitish spines. Trochanter has one large ventral spine but no dorsal spines. Femur has no dorsal spines and no retrolateral spines. The prolateral surface is armed with four large spines which increase in length distally. The ventral surface has a large basal spine, which carries a seta near the middle of its posterior surface as well as the usual apical seta. The proventral margin has no spines but is provided with a row of about five small tubercles or granules. The retroventral margin has a row of five large spines, the first being the smallest and the second the largest. The patella is armed with two large proventral spines and a much smaller retroventral spine. The tibia has three proventral and four retroventral spines as well as several small spines on the ventral surface. The tarsus has three strong spines on each side. The tarsal claw is about one-third of the length of the segment.

Coxa I is armed with a row of four spines on the front margin, the two spines near the apex being united at their bases. The ventral surface is furnished with several smaller spines. Coxa II has one tooth in front of the apex and three behind. A row of four small tubercles crosses the dorsal surface close to the margin of the scutum. Coxa III has a row of marginal granules in front and behind. Coxa IV has a small tooth in front of the distal end and a row of granules on the posterior margin.

The genital operculum measures 0·63 mm. long and 0·80 mm. wide. Its margin is smooth and rounded in front. The penis has the form shown in fig. 213. The glans ends in a narrow tube which curves downward and backward. On each side of the base of the glans is a wing-like lateral process, which extends outward and upward ending in a point. The ventral plate is uncleft and furnished with two pairs of superior and three pairs of inferior setae.

The sternum posteriorly is wide and crescent-shaped (fig. 212). Each free sternite is provided with a transverse row of small rounded granules. The respiratory spiracles are hidden by bridging granules on the posterior margin of the fourth coxae.

Legs are unarmed, but all segments from trochanter to tibia are coarsely granulate. Each calcaneus is very short and conical. The number of segments in tarsi I-IV is 3, 10L 8R, 4, 4. Distitarsi I and II have two and three segments respectively. The claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

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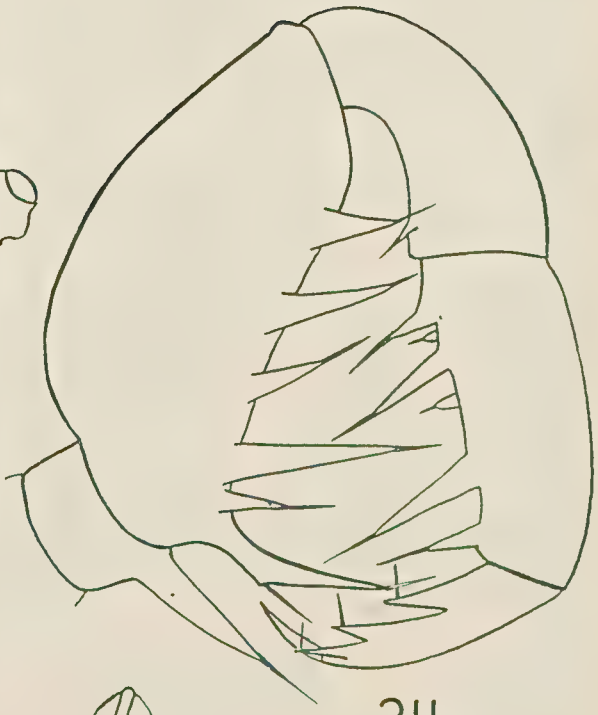

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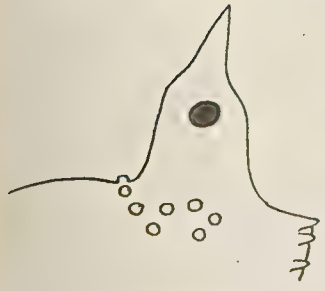

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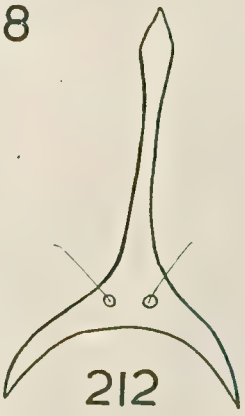

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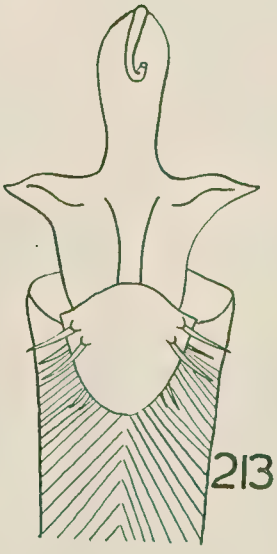

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Glyptobunus ornatus sp. n.

FIG. 208.—Dorsal view of scutum and free tergites of male.
FIG. 209.—Lateral view of eyemound.
FIG. 210.—Prolateral view of chelicera.
FIG. 211.—Retrolateral view of pedipalpus of male.
FIG. 212.—Sternum of male.
FIG. 213.—Ventral view of distal part of penis.

Allotype Female

Measurements in millimeters: Body-length 5·94, length of scutum 3·83, length of carapace 1·71.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	1·03	0·63	2·28	0·91	1·88	2·57	0·86	10·16
Leg 2	1·71	0·68	4·17	1·09	3·71	5·37	2·00	18·73
Leg 3	1·50	0·69	2·96	1·08	2·57	4·23	1·26	14·29
Leg 4	1·94	0·74	4·00	1·14	3·31	6·10	1·43	18·66
Pedipalp	0·69	0·80	2·28	1·60	1·48	....	1·49	8·34

The female resembles the male in colouration and general features. The pedipalpi are slightly smaller than those of the male. In other external features there is little to distinguish the two sexes.

Localities: The holotype male was collected in the Myrtle Forest at Collinsvale, Tasmania, 9th November, 1955, and the allotype female on Mount Wellington, 18th August, 1951. The harvestman also occurs at National Park and Hastings. It is usually found under decaying logs in damp and shady situations.

Variations: The species is not very common and the collection contains only two males and nine females. The body-length of the two males is 4·57 and 4·93 mm. respectively, that of the nine females varies from 3·48-5·68 mm. All the specimens have four segments in each of tarsi III and IV. The number of segments in tarsus II varies from 8-10 as is shown in Table 18.

Table 18

Number of segments	Sex	Number of segments in tarsus I	Number of segments in tarsus II
1	♂	3	9L 8R
1	♂	3	10L 8R
1	♀	3	8
1	♀	3	8L 9R
4	♀	3	9
2	♀	3	9L 8R
1	♀	3	9L 10R

Genus **PHOXOBUNUS** gen. n.

Scutum and free tergites unarmed. Eyemound conical, rising from the anterior margin and armed in front with a spine, which projects forwards. Sternum wide and crescentic posteriorly. Respiratory spiracles concealed. Leg I armed with a spine below the trochanter and two large spines below the femur. Other legs unarmed. All calcanei knob-like and short, being much shorter than astragali. Tarsal segmentation 3, 5, 4, 4. The distitarsi I and II with two and three segments respectively. Claws of tarsi III and IV three-pronged, the middle prong being larger than the lateral prongs.

Genotype: *Phoxobunus tuberculatus* sp. n.

Type Locality: Highcroft, Tasmania.

PHOXOBUNUS TUBERCULATUS sp. n.

(Figures 214-218)

Holotype Male

Measurements in millimeters: Body-length 2·11, length of scutum 1·60, length of carapace 0·80.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·57	0·23	0·74	0·40	0·57	0·69	0·46	3·66
Leg 2	0·74	0·34	1·31	0·57	1·03	1·26	0·86	6·11
Leg 3	0·80	0·29	0·97	0·46	0·69	1·03	0·51	4·75
Leg 4	0·80	0·34	1·20	0·51	1·14	1·60	0·51	6·10
Pedipalp	0·51	0·23	1·03	0·74	0·74	....	0·40	3·65

Colour (in alcohol): Scutum yellow with a wide W-shaped black mark on the posterior three-quarters (fig. 214). Carapace with black reticulations on each side. Eyemound black between the eyes and with dark reticulations behind. Free tergites each with a pair of black transverse marks, one on each side of the median line. Chelicerae and pedipalpi yellow with dark reticulations. Coxae yellowish with apex and base dark. Free sternites yellow with a dark mark on each side and in the middle. Legs dark-brown banded with yellow on the distal half of the femora, patellae and tibiae.

Scutum coarsely shagreened; furnished with three denticles on each side above the anterior margin. Eyemound conical, rising from the front margin and armed in front with a spine which projects forward beyond the margin (fig. 215). Scutal groove and tergal grooves distinct medianly, the fifth groove extending laterally. Tergal Areas I-IV each provided with a median pair of low rounded tubercles. Area V and the free tergites each with a transverse row of small tubercles, one of which is median in position.

Chelicerae have a small apical tooth on the dorsal side of the basal segment and a median dorsal row of three denticles on the second segment. The basal segment is 0·46 mm. and the second segment 0·86 mm. long.

Pedipalpi (fig. 216) large and strong. The trochanter armed with a tooth below. Femur swollen and much enlarged dorsoventrally in the proximal quarter. It has a median dorsal row of eight teeth, the first six being in the proximal half and larger than the other two, which are in the distal half. The retrolateral side is smooth. The prolateral side has two teeth in the distal quarter and a row of five small denticles immediately below the dorsal margin. The ventral surface is armed with a large median proximal tooth, four teeth along the retroventral margin and a single tooth at the proximal end of the proventral margin. The patella is furnished with two small conical tubercles on the prolateral side and a single blunt tubercle on the retrolateral side. The tibia has four retrolateral teeth, three prolateral teeth and a median row of small tubercles on the ventral surface. The tarsus has three teeth on each side. The claw is about ⅓ the length of the segment.

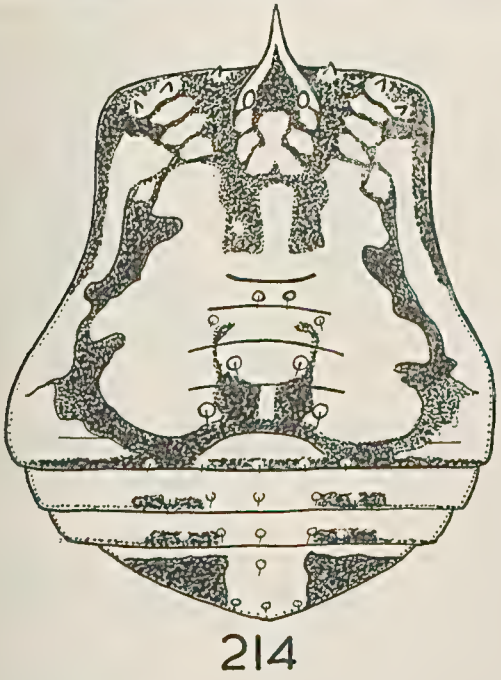
Coxae shagreened. Coxa I armed with a large tooth near the middle of the promargin and a smaller bifid tooth at the apex. Coxa II has near the apex a few granules in front, three blunt teeth behind and a broad tubercle above. Coxa III is furnished with a marginal row of granules in front

and behind. Coxa IV is devoid of tubercles and spines in front of the apex but has a marginal row of granules behind.

The genital operculum (fig. 217) is shagreened but devoid of spines and tubercles. It measures 0·29 mm. long and 0·40 mm. wide. The sternum is wide and crescentic posteriorly.

The respiratory spiracles are hidden under bridging granules on the posterior margin of the fourth coxae.

Legs are short and shagreened. Leg I (fig. 218) is armed with a spine below the trochanter and a row of two large spines and several tubercles below the femur. There are also two small tubercles below the proximal half of the tibia. Legs II-IV are unarmed. All calcanei are knob-like and short, being much shorter than the astragali. The number of segments in tarsi I-IV is 3, 5, 4, 4. Distitarsi I and II have two and three segments respectively. The claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.



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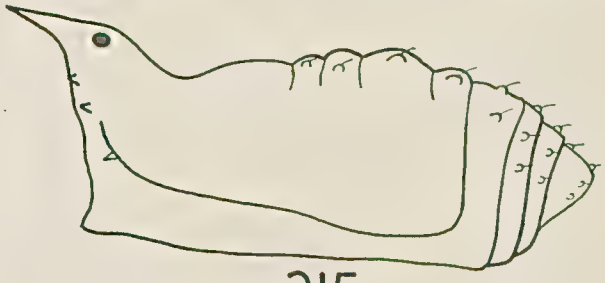

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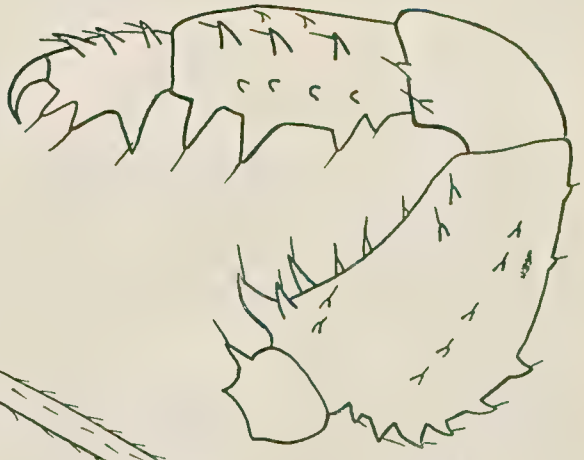

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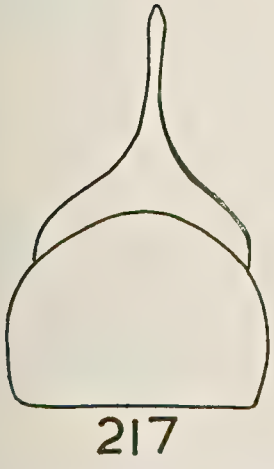

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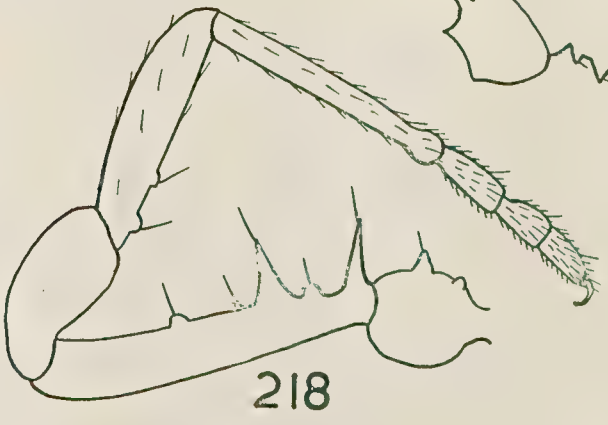

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Phoxobunus tuberculatus gen. et sp. n.

Fig. 214.—Dorsal view of scutum and free tergites of male.
Fig. 215.—Lateral view of scutum and free tergites of male.
Fig. 216.—Prolateral view of pedipalpus of male.
Fig. 217.—Sternum and genital operculum of male.
Fig. 218.—Leg I of male.

Allotype Female

Measurements in millimeters: Body-length 2·00, length of scutum 1·43, length of carapace 0·74.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·46	0·23	0·63	0·34	0·46	0·57	0·40	3·09
Leg 2	0·63	0·29	1·09	0·46	0·91	0·97	0·69	5·04
Leg 3	0·57	0·23	0·74	0·40	0·63	0·86	0·34	3·77
Leg 4	0·74	0·34	1·14	0·46	0·97	1·37	0·46	5·48
Pedipalp	0·40	0·23	0·63	0·46	0·51	....	0·29	2·52

The female resembles the male in general appearance and colouration but each tergal Area is marked with a transverse dark bar which extends laterally. The pedipalpi are much smaller and weaker than those of the male but have the same arrangement of spines and tubercles. The trochanter and femur of leg I are armed as in the male and both sexes have the same tarsal segmentation. The genital operculum measures 0·29 mm. long and 0·40 mm. wide.

Localities: The type specimens were collected under decaying logs at Highcroft, Tasmania, by A. L. Meston on 23rd February, 1940. The species also occurs on Mount Wellington but is not very common. The collection contains only seven specimens, all of which have the same tarsal segmentation as the types.

PHOXOBUNUS ROSTRATUS sp. n.

(Figures 219-223)

Holotype Male

Measurements in millimeters: Body-length 1·88, length of scutum 1·43, length of carapace 0·75.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·51	0·29	0·80	0·40	0·51	0·69	0·46	3·66
Leg 2	0·69	0·23	1·20	0·46	1·09	1·37	0·74	5·78
Leg 3	0·69	0·23	0·80	0·40	0·69	0·97	0·40	4·18
Leg 4	0·69	0·29	1·14	0·51	0·97	1·49	0·63	5·72
Pedipalp	0·40	0·23	1·09	0·63	0·51	....	0·51	3·37

Colour (in alcohol): Scutum yellowish with dark reticulations each side of the carapace. A wide black U-shaped mark is present on the posterior two-thirds of the scutum. The fifth tergal Area and first two free tergites marked with a transverse dark bar; the third free tergite with a pair of triangular dark patches, one on each side. Chelicerae, pedipalpi and coxae yellowish with dark reticulations. Free sternites yellowish with transverse broken dark bars. Legs dark-brown with pale bands round the distal half of femora, patellae and tibiae.

Scutum (fig. 219) shagreened, devoid of spines and tubercles. Scutal and tergal grooves absent. The margin of the scutum on each side above the aperture of the scent gland is raised up to form a small lobe, which is in contact with a large tubercle above the apex of coxa II. Eyemound (fig. 220) conical, rising from the front margin and armed with a spine which projects beyond the margin. Free tergites devoid of spines and tubercles.

Chelicerae moderately large. The first segment is 0·40 mm. long and is unarmed. The second segment is 0·86 mm. long and on the dorsal side is armed with a large tooth near the base and two teeth in the distal quarter, one of which is median, the other prodorsal.

Pedipalpi (fig. 221) large and strong. The trochanter has a small tooth below. The femur, which is much enlarged projects backwards in the form of a dorsal posterior bulge above the trochanter. The bulge is armed with a large bifid tooth, in front of which are two smaller simple teeth. The rest of the dorsal surface is unarmed. The prolateral surface has a row of four small teeth. The retrolateral surface is smooth. The ventral surface is armed with a large median proximal tooth, the tip of which is curved forwards. On the retroventral margin is a row of three teeth, the first of which is the largest. No teeth or tubercles are present on the proventral margin. The patella has a small retrolateral tooth and two small prolateral tubercles. The tibia is furnished with three teeth on each side. On the retrolateral side the first tooth is in the proximal quarter, the other two, which are larger, are close together in the distal quarter. On the prolateral side the distal tooth is the largest. The ventral surface is furnished with a few coarse tubercles. The tarsus has three teeth on each side. The claw is about one-third the length of the segment.

The sternum (fig. 222) is wide and crescentic behind. The genital operculum measures 0·23 mm. long and 0·29 mm. wide. It is devoid of spines and tubercles.

Coxa I has three promarginal teeth, the first of which is very small, the other two much larger. The apical tooth is bifid. Behind the promarginal teeth there are several coarse tubercles. Coxa II has a large tooth and two smaller tubercles behind the apex. A large broad tubercle is present above the apex and opposite the lobe on the margin of the scutum. Coxa III is provided with a marginal row of coarse granules in front and behind. Coxa IV has a few small tubercles or granules in front of the apex and a row of granules along the posterior margin.

The respiratory spiracles are concealed under granules on the posterior margin of the fourth coxae.

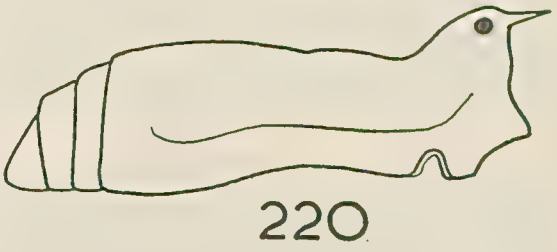
Leg I (fig. 223) is armed with a small spine below the trochanter, and two much larger spines below the proximal half of the femur. Two small tubercles are situated below the proximal half of the tibia. Legs II-IV are unarmed. All calcanei are knob-like and short, being much shorter than the astragali. The number of segments in tarsi I-IV is 3, 5, 4, 4. Distitarsi I and II have two and three segments respectively. The claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

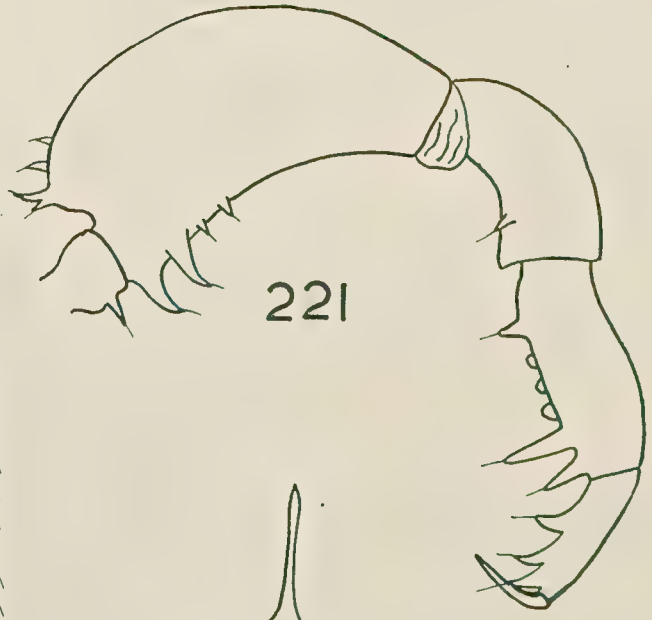
Allotype Female

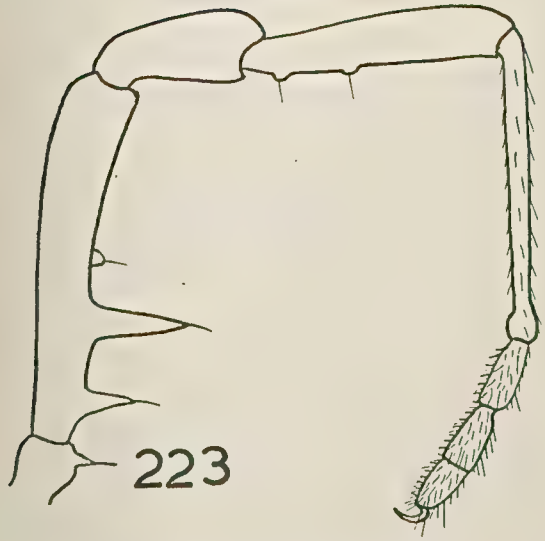
Measurements in millimeters: Body-length 1·77, length of scutum 1·31, length of carapace 0·69.

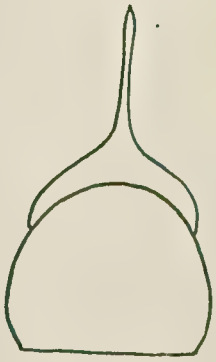
	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·46	0·23	0·57	0·34	0·40	0·57	0·46	3·03
Leg 2	0·63	0·23	0·97	0·40	0·86	1·03	0·69	4·81
Leg 3	0·57	0·17	0·69	0·34	0·63	0·80	0·46	3·66
Leg 4	0·63	0·23	0·97	0·40	0·86	1·26	0·51	4·86
Pedipalp	0·34	0·17	0·57	0·40	0·34	....	0·34	2·16

The female resembles the male in colour but the black regions on the scutum and free tergites are more extensive. The pedipalpi are much smaller than those of the male. The femur is not greatly enlarged and lacks the posterior dorsal bulge. It is furnished with a median dorsal row of three simple teeth in the proximal half. The ven-









Phoxobunus rostratus gen. et sp. n.

Fig. 219.—Dorsal view of scutum and free tergites of male.
Fig. 220.—Lateral view of scutum and free tergites of male.
Fig. 221.—Retrolateral view of pedipalpus of male.
Fig. 222.—Sternum and genital operculum.
Fig. 223.—Leg I of male.

tral spines are more slender than in the male. The femur of leg I is armed with spines as in the male but the spines are smaller. The tarsal segmentation is the same in both sexes. The genital operculum measures 0·23 mm. long and 0·34 mm. wide.

Locality: The type specimens and three others were collected in *Notofagus* forest near Liffey Falls, Tasmania, 14th May, 1953.

Variations: Males vary in body-length from 1·45-1·88mm. and females from 1·45-1·77 mm. The five specimens collected all had the same tarsal segmentation, 3, 5, 4, 4.

Genus **EUBUNUS** gen. n.

Eyemound conical, armed above with a short spine. Anterior margin of carapace unarmed. Scutum unarmed but tergal Areas I-IV each with a median pair of low rounded tubercles. Area V and each free tergite with a transverse row of low tubercles. First segment of chelicerae with a long median dorsal apical spine. Legs unarmed but tuberculate on trochanters. femora, patellae and tibiae. Each calcaneus knob-like and much shorter than astragalus. Tarsal segmentation: 3, 7-8, 4, 4. Distitarsi I and II with two and three segments respectively. Claws of tarsi III and IV three-pronged, the middle prong being larger than the lateral prongs.

Genotype: *Eubunus crypsidomus* sp. n.

Type Locality: Mount Wellington, Tasmania.

The genus *Eubunus* is near *Allobunus* gen. n. but differs in the form of the sternum and in the presence of a long spine at the apex of the first segment of the chelicerae.

EUBUNUS CRYPSIDOMUS sp. n.

(Figures 224-228)

Holotype Male

Measurements in millimeters: Body-length 3·77, length of scutum 3·54, length of carapace 1·60.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·86	0·57	1·88	0·86	1·43	1·83	1·03	8·46
Leg 2	1·43	0·63	2·74	0·97	2·34	3·43	2·00	13·54
Leg 3	1·54	0·57	1·83	0·86	1·54	2·34	1·14	9·82
Leg 4	1·71	0·63	2·40	0·97	2·11	3·60	1·20	12·62
Pedipalp	0·40	0·40	1·88	1·43	1·20	....	1·14	6·45

Colour (in alcohol): Scutum dark-brown, almost black, on each side with the median region and lateral margins yellowish. Eyemound dark-brown surrounded at the base by a U-shaped yellow area. Anterior lateral angles of scutum marked with dark reticulations. Dark markings in scutal groove and other tergal grooves. Free tergites dark-brown with transverse rows of yellow tubercles. Chelicerae and pedipalpi yellowish with dark reticulations. Legs mainly dark-brown with the trochanters yellow above and brown below. Patellae and tibiae paler in the middle and femora IV paler distally. Each calcaneus almost white. Ventral surface of body yellowish. Sternites with dark-brown transverse markings.

Body and appendages finely shagreened. Anterior margin of scutum with two small granules above on each side. Eyemound, conical, vertical and slightly behind the anterior margin. The short spine which surmounts the eyemound is missing in the holotype, and apparently has been either lost or not developed. Since the female and immature males possess a spine, it is reasonable to suppose that the adult male will also possess one. In fig. 224 its probable position is shown in dotted outline. The scutal groove and other tergal grooves are well marked medianly. Tergal Areas I-IV each furnished with a median pair of low yellow tubercles; Area V and each free tergite with a tranvserse row of low yellow tubercles. Spines are absent.

Chelicerae (fig. 225) each with a very long apical spine on the dorsal surface of the first segment and three pairs of small tubercles on the dorsal surface of the second segment. The first segment measures 0·69 mm. and the second 1·14 mm. in length.

Pedipalpi (fig. 226) large and powerful. The trochanter has a single ventral tubercle. The femur is much enlarged and forms a posterior dorsal bulge, which is surmounted by a small tooth. On the prodorsal margin is a row of four or five teeth, which point inwards. On the prolateral side in the distal half there are two or three teeth. On the ventral surface there is a large median nonbifid proximal tooth, a retromarginal row of two large teeth and a promarginal row of two or three small teeth in the basal half. The patella has two prolateral spines. The tibia has three prolateral teeth and three smaller retrolateral teeth. The ventral surface is slightly tuberculate. The tarsus has three teeth on each side. The claw is small.

Coxa I has two or three spinous tubercles on the promargin and a few smaller rounded tubercles on the ventral surface. Coxa II is furnished with a few tubercles in front of the apex and three small teeth behind. There is also a large promarginal tubercle above the apex. Coxa III has a marginal row of granules in front and behind. Coxa IV is furnished with a few tubercles in front of the apex and a row of granules on the posterior margin. A few of the distal granules form bridging granules which conceal the respiratory spiracle (fig. 227).

Sternum (fig. 228) short and widely crescentic posteriorly. Genital operculum 0·57 mm. long and 0·86 mm. wide. The margin is rounded and smooth. The surface with a few small granules.

Legs unarmed but the trochanters, femora, patellae and tibiae are tuberculate. The tubercles on the ventral surface of the femur of leg I are coarser than elsewhere. Each calcaneus is short and knob-like, being much shorter than the astragalus. Tarsal segmentation: 3, 8L 7R, 4, 4. Distitarsi I and II have two and three segments respectively. The claws of tarsi III and IV are three-pronged, the median prong being larger than the lateral prongs.

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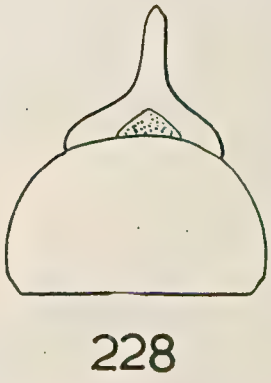

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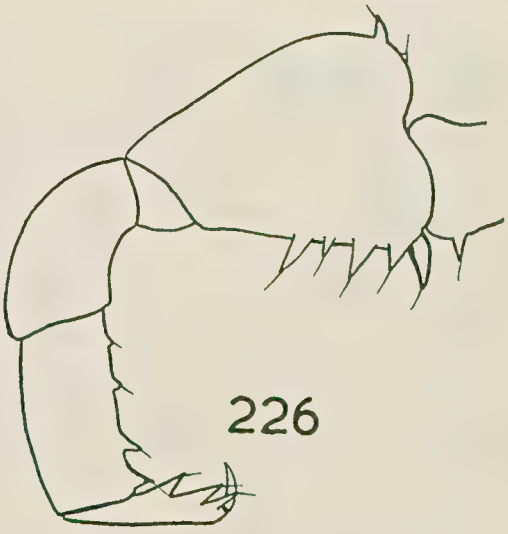

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Eubunus crypsidomus gen. et ep. n.

Fig. 224.—Lateral view of scutum and free tergites of male. (Spine of eyemound not present on specimen.)
Fig. 225.—Dorsal view of basal segments of chelicerae and femora of pedipalpi of male.
Fig. 226.—Retrolateral view of pedipalpus of male.
Fig. 227.—Ventral view of distal end of right coxa IV.
Fig. 228.—Sternum and genital operculum of male.

Allotype Female

Measurements in millimeters: Body-length 4·85, length of scutum 4·17, length of carapace 1·60.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·69	0·46	1·54	0·86	1·20	1·66	0·86	7·27
Leg 2	1·49	0·69	2·46	1·08	2·28	3·08	1·94	13·02
Leg 3	1·49	0·51	1·71	0·86	1·49	2·23	1·03	9·32
Leg 4	1·71	0·69	2·51	1·03	2·00	3·31	1·26	12·51
Pedipalp	0·51	0·34	1·14	0·91	0·80	....	0·86	4·56

The female resembles the male in colouration and general features. The pedipalpi, however, are much smaller than those of the male and the apical spine on the dorsal surface of the first segment of the chelicerae is shorter than in the male. The genital operculum is 0·63 mm. long and 0·97 mm. wide. The tarsal segmentation: 3, 8, 4, 4.

Locality: The type specimens were found under pieces of charred wood lying on the ground near the Organ Pipes, Mount Wellington, November, 1955. Another female was collected at the same locality in 15th May, 1956, and two immature forms on 2nd September, 1957.

Genus **ALLOBUNUS** gen. n.

Scutum unarmed, eyemound conical, rising from the anterior margin and armed at the apex with a short spine. Tergal Areas I-IV furnished with a median pair of granules. Area V and the free tergites each with a transverse row of granules. Sternum wide and shaped like an arrow head, approaching the form of the sternum in certain Adaeinae. Respiratory spiracles concealed. Legs unarmed. Calcanei much shorter than astragali. Tarsal segmentation: 3, 7-9, 4, 4. Distitarsi I and II have two and three segments respectively. The claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

Genotype: *Allobunus distinctus* sp. n.

Type Locality: Near Lake St. Clair, Tasmania.

ALLOBUNUS DISTINCTUS sp. n.

(Figures 229-232)

Holotype Male

Measurements in millimeters: Body-length 2·68, length of scutum 2·34, length of carapace 1·14.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·74	0·40	1·20	0·63	0·80	1·26	0·80	5·83
Leg 2	1·14	0·46	1·77	0·74	1·54	1·88	1·71	9·24
Leg 3	0·86	0·34	1·26	0·69	0·91	1·37	0·97	6·40
Leg 4	1·03	0·46	1·66	0·80	1·43	2·00	1·14	8·52
Pedipalp	0·40	0·34	0·80	0·63	0·57	....	0·57	3·31

Colour (in alcohol): Scutum yellowish-brown with dark reticulations on each side of the carapace and in front of the eyemound. A large dark-brown area on each side extends from slightly behind the eyemound to the posterior margin of the scutum and is intersected by a yellowish-brown bar on Areas IV and V. On each of the tergal Areas I-IV there is a median pair of dark marks and on Area V a single median dark mark. The apical half of the eyemound is black. The first two free tergites are yellowish-brown with median and lateral dark marks . The third free tergite is brown. Chelicerae, pedipalpi and trochanters mainly yellow. Legs dark-brown with a wide yellowish band round the distal half of the femora and tibiae. Calcaneus of each leg white, except that of leg II which is brown. Coxae yellowish with the inner ends of coxae II and III dark-brown. The sternum is dark in the middle and the genital operculum has a longitudinal dark mark on each side. The free sternites are yellowish with dark transverse markings.

Scutum (fig. 229) shagreened and unarmed. The scutal and tergal grooves faintly marked. Tergal Areas I-IV each with a median pair of small granules. Area V and each free tergite with a transverse row of small granules. Eyemound broadly conical, rising from the anterior margin and surmounted by a short spine at the apex.

Chelicerae rather stout. The first segment measures 0·46 mm. long and is provided with a small prodorsal tubercle at the apex. The second segment is 0·97 mm. long and has a row of three small tubercles on the prodorsal margin.

Pedipalpi (fig. 230) not very robust. The trochanter has a large tooth below. The dorsal surface of the femur has two teeth in a median row on the proximal third. The retrolateral surface is furnished with a small tooth above the middle of the retroventral margin. The prolateral surface has three teeth in the distal half, the second tooth being the largest. The ventral surface is armed with a large median proximal tooth and with two teeth on the retroventral margin. The patella has two large prolateral teeth. The tibia is armed with two prolateral and three retrolateral teeth. The tarsus has three teeth on each side. The claw is rather straight and about one-third the length of the segment.

The coxae are shagreened. Coxa I is furnished with two small promarginal denticles, the larger of which is near the middle, the other at the apex. Coxa II has a small tooth and several granules behind the apex. Coxa III is furnished with a marginal row of about six granules in front of and behind the distal half. Coxa IV has a few granules in front of the apex and a row of granules along the posterior margin, the two distal granules of the row being enlarged to cover the spiracle.

The sternum (fig. 231) is wide and shaped like the head of an arrow. Its posterior margin is crescentic. The genital operculum is large and triangular with a smooth surface and margin. The apex is rounded. The operculum measures 0·63 mm. long and 0·57 mm. wide.

Legs are short, stout and unarmed. Leg I (fig. 232) is furnished with a few blunt tubercles below the femur and tibia. The other legs are devoid of tubercles. All calcanei are knob-like and short, being much shorter than the astragali. The number of segments in tarsi I-IV is 3, 8, 4, 4. Distitarsi I and II have two and three segments respectively. The claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

Allotype Female

Measurements in millimeters: Body-length 3·26, length of scutum 2·40, length of carapace 1·14.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·69	0·34	1·03	0·51	0·69	1·14	0·80	5·20
Leg 2	1·03	0·40	1·54	0·69	1·43	1·54	1·43	8·06
Leg 3	0·86	0·34	1·03	0·57	0·86	1·26	0·91	5·83
Leg 4	1·03	0·46	1·49	0·63	1·37	1·83	1·03	7·84
Pedipalp	0·34	0·29	0·80	0·57	0·57	....	0·46	3·03

The female resembles the male very closely in colouration and general form. The pedipalpi of the two sexes do not differ much in length but those of the male are slightly stouter. The female genital operculum is shorter and wider than the male operculum and measures 0·57 mm. long and 0·63 mm. wide. The number of segments in tarsi I-IV is 3, 7L 8R, 4, 4.

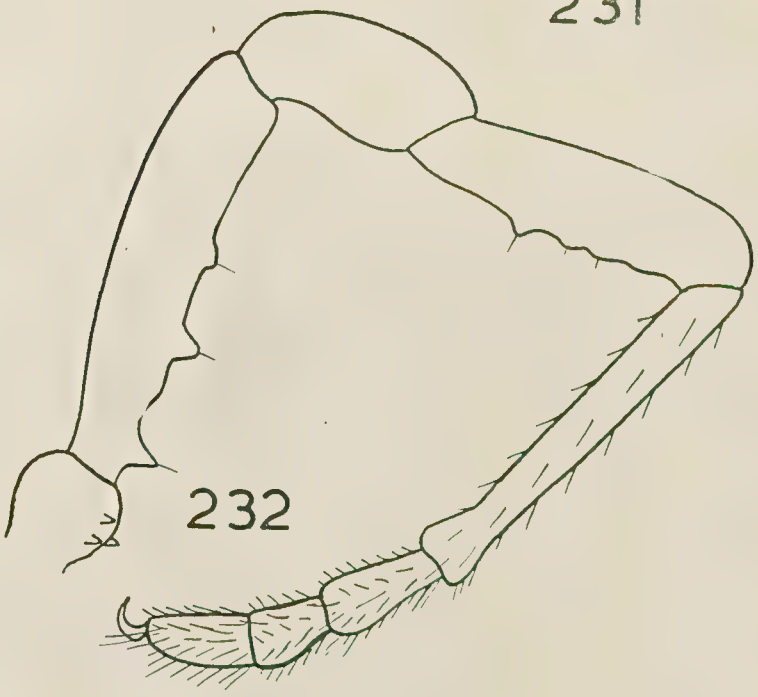
Locality: The type specimens were found under decaying logs in rain-forest near the southern end of Lake St. Clair, Tasmania, 7th February, 1945. The collection contains only one other specimen, a female from the same locality.

Variations: The second female specimen measures 3·01 mm. in body-length. Its tarsal segmentation is 3, 8L 9R, 4, 4.

229

231

230



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Allobunus distinctus gen. et sp. n.

FIG. 229.—Lateral view of scutum and free tergites of male.
FIG. 230.—Prolateral view of pedipalpus of male.
FIG. 231.—Sternum and genital operculum of male.
FIG. 232.—Leg I of male.

Genus **CHILOBUNUS** gen. n.

Anterior margin of scutum unarmed. Eyemound high, conical, slightly behind the front margin and armed above with a strong spine. Tergal Areas I, III, and IV armed with a median pair of spines. Area II is unarmed. Area V and free tergites each armed with a transverse row of spines. Sternum wide and crescentic behind. Respiratory spiracles concealed. Legs unarmed. Calcanei much shorter than astragali. Tarsal segmentation 3, 6, 4, 4. Distitarsi I and II with two and three segments respectively. Claws of tarsi III and IV three-pronged, the middle prong larger than the lateral prongs.

Genotype: *Chilobunus spinosus* sp. n.

Type Locality: The Arve Forest, Geeveston, Tasmania.

CHILOBUNUS SPINOSUS sp. n.

(Figures 233-237)

Holotype Male

Measurements in millimeters: Body-length 2·00, length of scutum 1·71, length of carapace 0·91.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·63	0·23	1·09	0·46	0·80	0·91	0·63	4·75
Leg 2	0·86	0·29	1·83	0·57	1·31	1·66	1·14	7·66
Leg 3	0·74	0·29	1·26	0·57	0·91	1·43	0·66	5·86
Leg 4	0·91	0·40	1·77	0·63	1·20	2·34	0·86	8·11
Pedipalp	0·34	0·23	0·86	0·57	0·57	....	0·57	3·14

Colour (in alcohol): Scutum with a large dark-brown area on each side and a median yellow region extending from eyemound to the posterior margin of the scutum. On tergal Areas III-V transverse yellow bars extend from the median yellow region into the dark-brown areas on each side. Dark reticulations are present on each side of the carapace and in the median line behind the eyemound. The spines on the tergal Areas and free tergites are pale-yellow and each is surrounded at the base by a yellowish patch. Chelicerae and pedipalpi yellowish with dark reticulations. On the pedipalpi the reticulations occur mainly at the sides of and below the femur, patella and tibia. The legs are yellowish with dark-brown infuscation proximally and distally on the femora, tibiae and metatarsi. Trochanters and coxae yellow with dark reticulations. Sternites yellow with a dark median band extending from the genital operculum to the anus and with dark lateral patches.

Scutum (fig. 233) unarmed in front but with a median pair of blunt spines on tergal Areas I, III and IV. Those on Area I are small and curved forwards. Those Areas III and IV are large and curved backwards. Area II is unarmed. Area V and the first two free tergites are each provided with a transverse row of blunt spines. The third free tergite has a median pair of large blunt spines. The eyemound is high, conical, rising a little behind the front margin and produced at the apex into a large spine, which is inclined slightly forwards.

Chelicerae moderately large. The first segment is 0·40 mm. long, unarmed and with a dorsal bulge in the distal half. The second segment is 0·74 mm. long and furnished with a promarginal row of three tubercles on the dorsal surface, the middle tubercle in the row being spinous.

Pedipalpi (fig. 234) not greatly enlarged. The trochanter has a spine below. The dorsal surface of the femur has a median row of four large teeth. The retrolateral surface is unarmed. The prolateral surface has a small denticle above near the middle of the prodorsal margin and three spinous tubercles in the distal half, the third tubercle being smaller than the other two. The ventral surface is armed with a large median proximal tooth and a retromarginal row of three teeth, the first and third in the row being larger than the second. The patella has two large prolateral teeth. The tibia is slightly tuberculate below and provided with three teeth on each side, the distal tooth being the smallest in each case. The tarsus is armed with three teeth on each side and the claw is about half the length of the segment.

Coxa I with a promarginal row of three teeth, the apical tooth being deeply bifid. Coxa II has a small tooth behind the apex and a large blunt tubercle above. Coxa III is furnished with a marginal row of granules in front and behind. Coxa IV is devoid of spine and tubercles in front but has a row of granules along the posterior margin.

Sternum (fig. 235) is wide and crescentic posteriorly. The genital operculum is smooth, and rounded in front. It measures 0·34 mm. in length and width. The penis has the form shown in fig. 236. The ventral plate is furnished with three pairs of inferior and three pairs of superior setae. In the fully extended condition the lateral processes curve upwards and backwards. The glans ends distally in a narrow sigmoid duct, which is protected by a dorsal hood-like structure.

The respiratory spiracles are concealed by the posterior margin of the fourth coxae.

The legs are unarmed but femur I (fig. 237) has a few rounded tubercles below. All calcanei are straight, conical and much shorter than the astragali. The number of segments in tarsi I-IV is 3, 6, 4, 4. Distitarsi I and II have two and three segments respectively. The claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

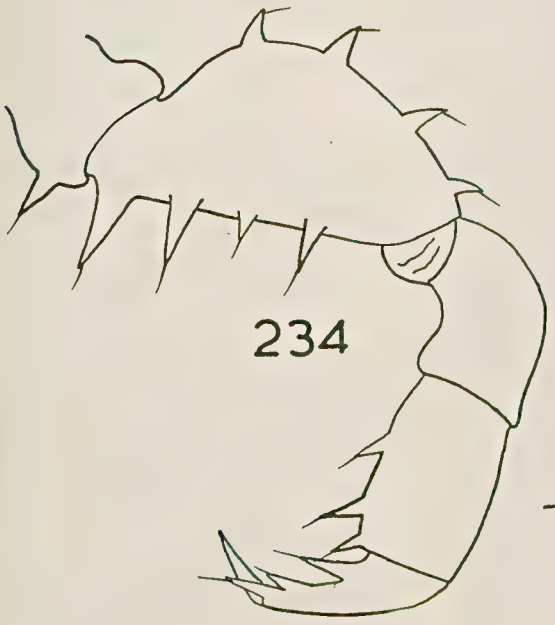
Allotype Female

Measurements in millimeters: Body-length 2·46, length of scutum 1·88, length of carapace 0·91.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·40	0·23	0·91	0·46	0·74	0·91	0·57	4·22
Leg 2	0·74	0·34	1·66	0·63	1·26	1·54	1·03	7·20
Leg 3	0·69	0·29	1·14	0·51	0·91	1·37	0·74	5·65
Leg 4	0·91	0·40	1·71	0·63	1·31	2·34	0·80	8·10
Pedipalp	0·23	0·23	0·80	0·46	0·57	....	0·51	2·80

The female resembles the male in colouration and general form. There is very little difference in the pedipalpi of the two sexes. The third free tergite has a large median single spine, instead of the pair of spines present in the male. The genital operculum measures 0·31 mm. long and 0·46 mm. wide and is much wider than that of the male. The tarsal segmentation in both sexes is the same: 3, 6, 4, 4.

Locality: The type specimens were found among moss growing on the base of a large eucalypt in the Arve Forest, Geeveston, Tasmania, 22nd November, 1955. The collection contains only one other specimen, a male from the same locality.



Chilobunus spinosus gen. et sp. n.

Fig. 233.—Lateral view of scutum and free tergites of male.
Fig. 234.—Retrolateral view of pedipalpus of male.
Fig. 235.—Sternum and genital operculum of male.
Fig. 236.—Lateral view of distal part of penis.
Fig. 237.—Femur of leg I of male.

Genus **RHYNCHOBUNUS** gen. n.

Eyemound rising directly from the front margin, conical and armed with a short spine, which is directed forwards and upwards. Carapace with a small conical spine on each side close behind the anterior margin. Tergal Areas and free tergites each furnished with a transverse row of tubercles. Chelicerae without a proximal boss on the retrolateral margin of the basal segment of the male. Legs unarmed. Calcanei much shorter than astragali. Calcaneus of leg I in male not notched below. Number of segments in tarsi I-IV is 3, 5-9, 4, 4. Distitarsi I and II have two and three segments respectively. Claws of tarsi III and IV are three-pronged, the middle prong being longer than the lateral prongs. The sternum is wide and crescent shaped posteriorly. The respiratory spiracles are concealed.

Genotype: *Rhynchobunus arrogans* sp. n.

Type Locality: Mount Dromedary, Tasmania.

The genus *Rhynchobunus* is close to *Chrestobunus* Roewer (1914) but differs in having a short spine on the eyemound and a small spine on each side of the carapace behind the anterior margin. It also differs in the form of the genitalia.

RHYNCHOBUNUS ARROGANS sp. n.

(Figures 238-244)

Holotype Male

Measurements in millimeters: Body-length 3·20, length of scutum 2·6, length of carapace 1·3.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·80	0·40	1·31	0·63	0·91	1·37	0·86	6·28
Leg 2	1·20	0·46	1·77	0·80	1·49	1·83	1·77	9·32
Leg 3	1·03	0·40	1·20	0·69	0·97	1·49	0·86	6·64
Leg 4	1·14	0·46	1·71	0·86	1·37	2·17	1·03	8·74
Pedipalp	0·63	0·46	1·60	0·86	0·86	....	0·80	5·21

Colour (in alcohol): Carapace reddish-brown with dark reticulations. Tergal region of scutum dark-brown with a median orange-coloured saddle-shaped area. Free tergites dark-brown with paler margins. Chelicerae and pedipalpi reddish-brown with dark reticulations. Coxae yellowish-brown with dark reticulations. Genital operculum yellowish with brown in the centre. Free sternite dark-brown with paler margins. Legs dark-brown with the femora, patellae and tibiae yellowish distally. The surface of the body and appendages is a dull matt, except the chelicerae, pedipalpi, coxae I and II and the bases of coxae III, which are polished.

Scutum with a small spine on each side above the anterior margin of the carapace and about mid-way between the eyemound and the anterior lateral angle. Surface of scutum finely shagreened. Eyemound conical, rising from the anterior margin and surmounted by a short spine, which is directed forwards and upwards (fig. 238). The apex of the spine has a slight upward curve and projects over the front margin. The scutal groove is distinct medianly. The groove between tergal Areas IV and V is well marked and extends onto the sides of the scutum. The other tergal grooves are indistinct. A median pair of tubercles occurs on each of Areas I-IV and a transverse row of tubercles on Area V and each free sternite. Each transverse row has a median tubercle, on each side of which the other tubercles decrease in size.

Chelicerae strong. Basal segment measures 0·69 mm. long and has a dorsal bulge in the distal half, and a median spine at the apex. The second segment measures 1·14 mm. long and has a row of three small tubercles on the prodorsal margin.

Pedipalpi (fig. 239) strong. Femur is enlarged proximally and has a median dorsal row of seven teeth, the fourth tooth being the largest. On the prodorsal margin is a second row of five small teeth. The prolateral surface has two larger teeth in the distal half. The retrolateral surface has a row of three granules below. The ventral surface has a median proximal tooth, a proventral row of five small denticles and a retroventral row of five teeth. Patella is armed with two prolateral teeth. The tibia is tuberculate below and has two prolateral and three retrolateral teeth. Tarsus has three teeth on each side.

Coxa I with three teeth on the front margin, the middle tooth being the largest. Coxa II with a small tooth behind the apex. Coxa III with a marginal row of granules in front and behind. Coxa IV with a marginal row of granules behind.

Genital operculum (fig. 240) large and smooth, 0·63 mm. wide and 0·57 mm. long. The penis has the form shown in figs. 241 and 242. The ventral plate has two pairs of superior and three pairs of inferior setae. The distal part of the glans is very long and slender. At each side of the base is a large lateral process. In the fully extended condition the lateral processes bend backwards. The sternum is wide and crescentic posteriorly. The respiratory spiracles are hidden by the fourth coxae.

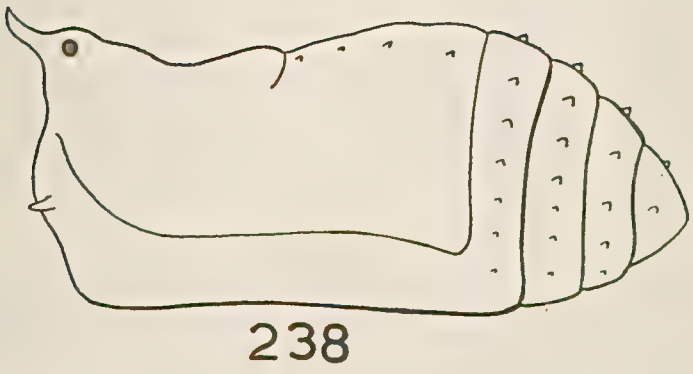
Legs smooth and unarmed except in the case of the femora which have a few small tubercles or granules. All the calcanei are short and conical. Number of segments in tarsi I-IV is 3, 6, 4, 4. Distitarsi I and II have two and three segments respectively. Claws of tarsi III and IV are three-pronged, the middle prong being longer than the lateral prongs.

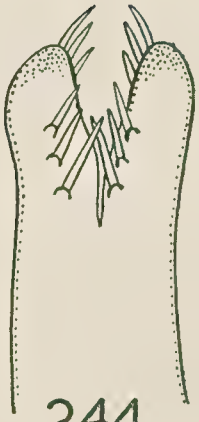
Allotype Female

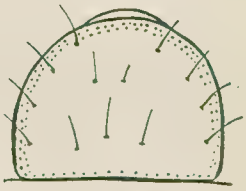
Measurements in millimeters: Body-length 3·31, length of scutum 2·34, length of carapace 1·08.

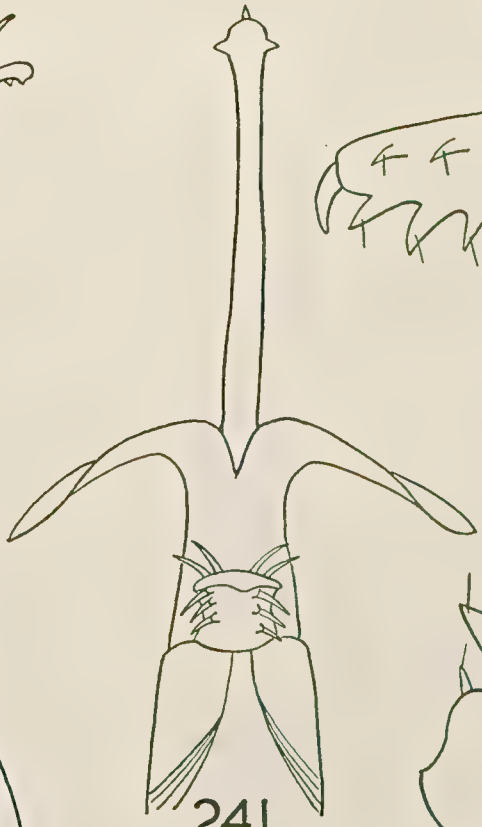
	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·74	0·40	1·14	0·62	0·86	1·14	0·68	5·58
Leg 2	1·03	0·46	1·60	0·69	1·31	1·54	1·37	8·00
Leg 3	0·91	0·34	1·09	0·51	0·97	1·20	0·68	5·70
Leg 4	0·97	0·46	1·43	0·69	1·31	1·94	1·03	7·83
Pedipalp	0·40	0·34	1·09	0·63	0·69	....	0·63	3·78

The female resembles the male in form and colouration but lacks the saddle-shaped mark on the scutum. The pedipalpi are smaller than those of the male and the tibia is not tuberculate on the ventral surface. The genital operculum (fig. 243) measures 0·62 mm. wide and 0·46 mm. long. It differs in shape and size from that of the male. The distal end of the ovipositor (fig. 244) is deeply cleft into two lobes, each of which is strongly chitinized and furnished with coarse setae on the inner dorsal and ventral margins. Tarsal segmentation as in the male.









Rhynchobunus arrogans gen. et sp. n.

Fig. 238.—Lateral view of scutum and free tergites of male.
Fig. 239.—Prolateral view of pedipalpus of male.
Fig. 240.—Genital operculum of male.
Fig. 241.—Ventral view of distal part of penis.
Fig. 242.—Lateral view of distal part of penis.
Fig. 243.—Genital operculum of female.
Fig. 244.—Ventral view of distal part of ovipositor.

Localities: The type specimens were found on Mount Dromedary, Tasmania, 10th November, 1955. The species is widely distributed in the State and the collection contains specimens from Dry's Bluff, Western Creek, Trevallyn, National Park, Mount Hobbs, Highcroft, Nugent, Eaglehawk Neck, Tarraleah, Weldborough, Pyengana and Liffey Falls. The harvestman usually occurs under decaying logs and adult specimens may be found throughout the year.

Variations: Males vary in length from 2·03-3·20 mm. and females from 2·09-3·31 mm. The collection contains 68 males and 61 females, all of which have three segments in tarsus I and four segments in both tarsus III and IV. The number of segments in tarsus II varies from six to nine in males and five to eight in females. Specimens from Weldborough and Pyengana in the north-east quarter of the State tend to have more segments in tarsus II than do specimens from other localities. Table 19 shows the number of segments in tarsi I and II of the 129 specimens examined.

Table 19

Number of specimens	Sex	Number of segments in tarsus I	Number of segments in tarsus II
23	♂	3	6
7	♂	3	6L 7R
12	♂	3	7L 6R
10	♂	3	7
2	♂	3	7L 8R
4	♂	3	8
3	♂	3	8L 9R
5	♂	3	9L 8R
2	♂	3	9
29	♀	3	6
3	♀	3	5L 6R
7	♀	3	7L 6R
8	♀	3	7
4	♀	3	7L 8R
4	♀	3	8L 7R
5	♀	3	8
1	♀	3	9L 8R

Genus **PHANEROBUNUS** Roewer, 1914

Anterior margin of carapace furnished with long spines on each side. Eyemound situated in the anterior third of the carapace and separated from the front margin by a distance about equal to its basal diameter. It is conical in shape and surmounted by an erect sharp spine. Scutal groove and other tergal grooves distinctly marked. Tergal Areas and free tergites each armed with a transverse row of spinous tubercles, the median tubercles, being larger than the lateral ones. The respiratory spiracles are situated under the posterior margin of the fourth coxae and are covered by bridging teeth. The calcaneus of each metatarsus is indistinct and very short, being less than one-seventh the length of the astragalus. The metatarsi show faint indications of pseudosegmentation. The tarsal segmentation is 3, 5-9, 4, 4. Distitarsi I and II have two and three segments respectively. Claws of tarsi III and IV are three-pronged, the median prong being larger than the lateral prongs. Males are distinguished from females by the larger size of their pedipalpi and by the presence of a large peg-like projection on the prolateral surface of the femur of the pedipalpi.

Genotype: *Phanerobunus armatus* Roewer.

Type Locality: Tasmania.

The genus was established on the characters of a single male specimen, and contains only the one species. Three new species are described in the present paper. They may be distinguished from the genotype and from each other by the key at foot of page.

PHANEROBUNUS ARMATUS Roewer, 1914

(Figures 245-250)

Male

Measurements in millimeters: Body-length 2·40, length of scutum 1·94, length of carapace 0·97.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·51	0·29	1·03	0·40	0·68	0·80	0·46	4·17
Leg 2	0·80	0·34	1·31	0·51	1·37	1·71	0·97	7·01
Leg 3	0·74	0·29	1·14	0·46	0·86	1·43	0·40	5·32
Leg 4	0·97	0·49	1·48	0·63	1·20	2·11	0·46	7·34
Pedipalp	0·34	0·40	1·37	0·91	0·91	....	0·74	4·67

Colour (in alcohol): Scutum yellowish-brown with a dark-brown margin and a long dark area on each side. Carapace with dark reticulations on each side of and behind the eyemound. Chelicerae and pedipalpi yellowish with dark-brown reticulations. Free tergites dark-brown with yellowish margins and yellow round the base of each spine. Coxae yellowish with faint dark-brown reticulations on the posterior two pairs. Genital operculum yellow. Sternites brown with yellow margins. A median yellow band extends from the genital operculum to the anus. Legs dark-brown.

Scutum (fig. 245) finely granular. Anterior margin with a row of four spines on each side, the median pair being larger than the others. Eyemound conical, situated immediately in front of the middle of the carapace and armed with an apical spine, which is inclined slightly forward. Behind the base of the spine is a small granule. Between the eyemound and the scutal groove the carapace is furnished with several granules or small tubercles. The scutal groove and tergal grooves are well marked. Tergal Areas I-IV each with a transverse row of spinous tubercles, the

KEY TO SPECIES IN THE GENUS *PHANEROBUNUS*

1. Tergal spines truncate .... *R. hebes* sp. n.
   Tergal spines not truncate 2
2. Tibia I with two ventral granules .... *P. saxatilis* sp. n.
   Tibia I with one ventral tubercle 3
3. Femur I with four ventral tubercles .... *P. armatus* Roewer.
   Femur I with two ventral tubercles .... *P. asperrimus* sp. n.

245

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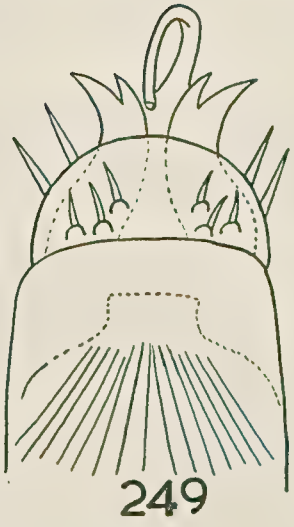

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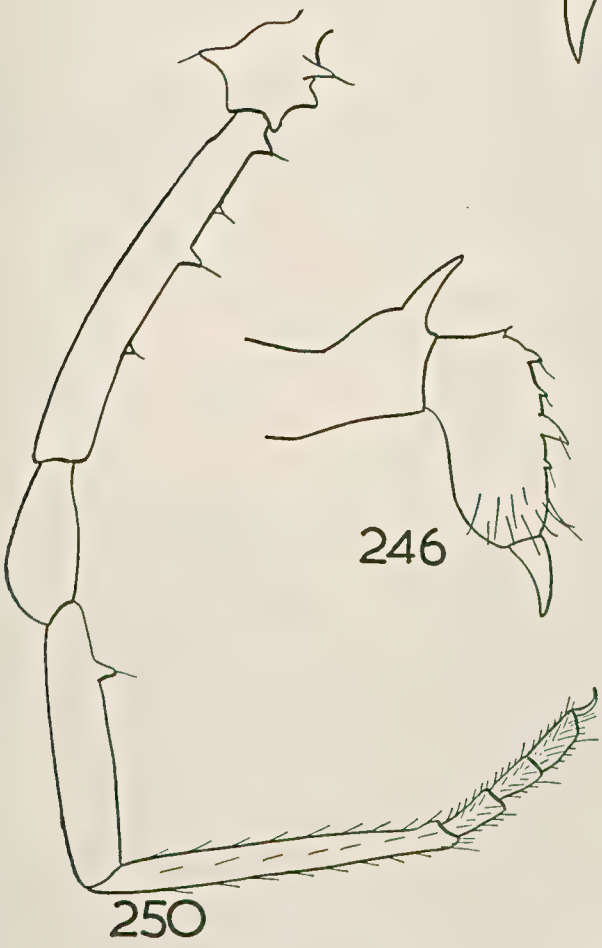

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Phanerobunus armatus Roewer.

FIG. 245.—Lateral view of scutum and free tergites of male.
FIG. 246.—Prolateral view of chelicera of male.
FIG. 247.—Prolateral view of pedipalpus of male.
FIG. 248.—Sternum of male.
FIG. 249.—Ventral view of distal part of penis.
FIG. 250.—Leg I of male.

median pair in each row being larger than the others. On Area V and each free tergite there is also a transverse row of tubercles, each row consisting of a median tubercle with about five or six on each side.

Chelicerae with a large median dorsal spine near the apex of the basal segment and several smaller tubercles on the dorsal surface of the second segment (fig. 246). The length of the basal segment is 0·46 mm. and that of the second segment 0·74 mm.

Pedipalpi (fig. 247) very large and powerful; almost twice the length of the body. The trochanter is armed with a small tooth above and a larger one below. The femur has a median dorsal row of six teeth and a prodorsal row of five smaller teeth. On the prolateral surface is an oblique row of four teeth, below which is a very large peg-like tooth situated above the middle of the proventral margin and projecting inwards and downwards. On the ventral surface there is a large proximal tooth, a proventral row of five small tubercles and a retroventral row of six teeth. On the retrolateral side there is a row of small granules above the row of retroventral teeth. The patella has two prolateral teeth; the tibia four prolateral and five retrolateral teeth and the tarsus three teeth on each side. The ventral surface of the tibia tuberculate.

Coxa I has two large teeth on the front margin, the apical tooth being bifid. Coxa II has a small tooth and two tubercles behind the apex. Coxa III has a marginal row of granules in front and behind. Coxa IV is furnished with a tooth in front of the apex and a row of granules on the posterior margin. The sternum has the form shown in fig. 248. The genital operculum is smooth and measures 0·40 mm. wide and 0·34 mm. long. The distal end of the partly extended penis has the form shown in fig. 249. The ventral plate is uncleft and has two pairs of superior and three pairs of inferior setae. The distal part of the glans is long, slender and curved ventrally in the form of a hook. On each side of the base of the glans is a broad curved process which ends in two sharp points. The dorsal side of the base of the glans is covered by a hood-like structure. The respiratory spiracles are concealed. The sternites are smooth.

Legs smooth, except leg I which has four small tubercles below the femur and one large tubercle below the proximal third of the tibia (fig. 250). Calcanei small and not strongly marked. Tarsal segmentation: 3, 6, 4, 4. Distitarsi I and II with two and three segments respectively.

Allotype Female

Measurements in millimeters: Body-length 2·74, length of scutum 2·00, length of carapace 0·86.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·46	0·28	0·80	0·40	0·57	0·74	0·40	3·65
Leg 2	0·74	0·34	1·37	0·51	1·20	1·43	0·91	6·50
Leg 3	0·80	0·29	1·08	0·46	0·86	1·20	0·40	5·09
Leg 4	0·97	0·40	1·43	0·57	1·14	1·88	0·51	6·90
Pedipalp	0·29	0·29	1·09	0·74	0·74	....	0·63	3·78

The female resembles the male but is more darkly coloured. The spine on the eyemound and those on the scutum and free tergites are smaller than in the male. The pedipalpi also are much smaller. The femur has a median dorsal row of five tubercles and a prodorsal row of four. On the prolateral side there is an oblique row of four tubercles, below which is an ordinary spine in place of the large peg-like tooth of the male. The ventral surface has a large proximal spine, a proventral row of three small teeth and a retroventral row of seven larger teeth.

The genital operculum measures 0·40 mm. wide and 0·29 mm. long.

Localities: The male and allotype female were collected at East Risdon, Tasmania, 4th June, 1945. The opilionid also occurs on the Queen's Domain, Hobart. It is usually found on the under surface of stones.

Variations: The collection contains eight males and 16 females. The males vary in body-length from 2·10-2·67 mm. and the females from 2·20-3·02 mm. All the specimens have four segments in each of tarsi III and IV. In the females the number of segments in tarsus II varies from five to six as is shown in Table 20.

Table 20

Number of specimens	Sex	Number of segments in tarsus I	Number of segments in tarsus II
8	♂	3	6
5	♀	3	5
1	♀	3	6L 5R
10	♀	3	6

PHANEROBUNUS SAXATILIS sp. n.

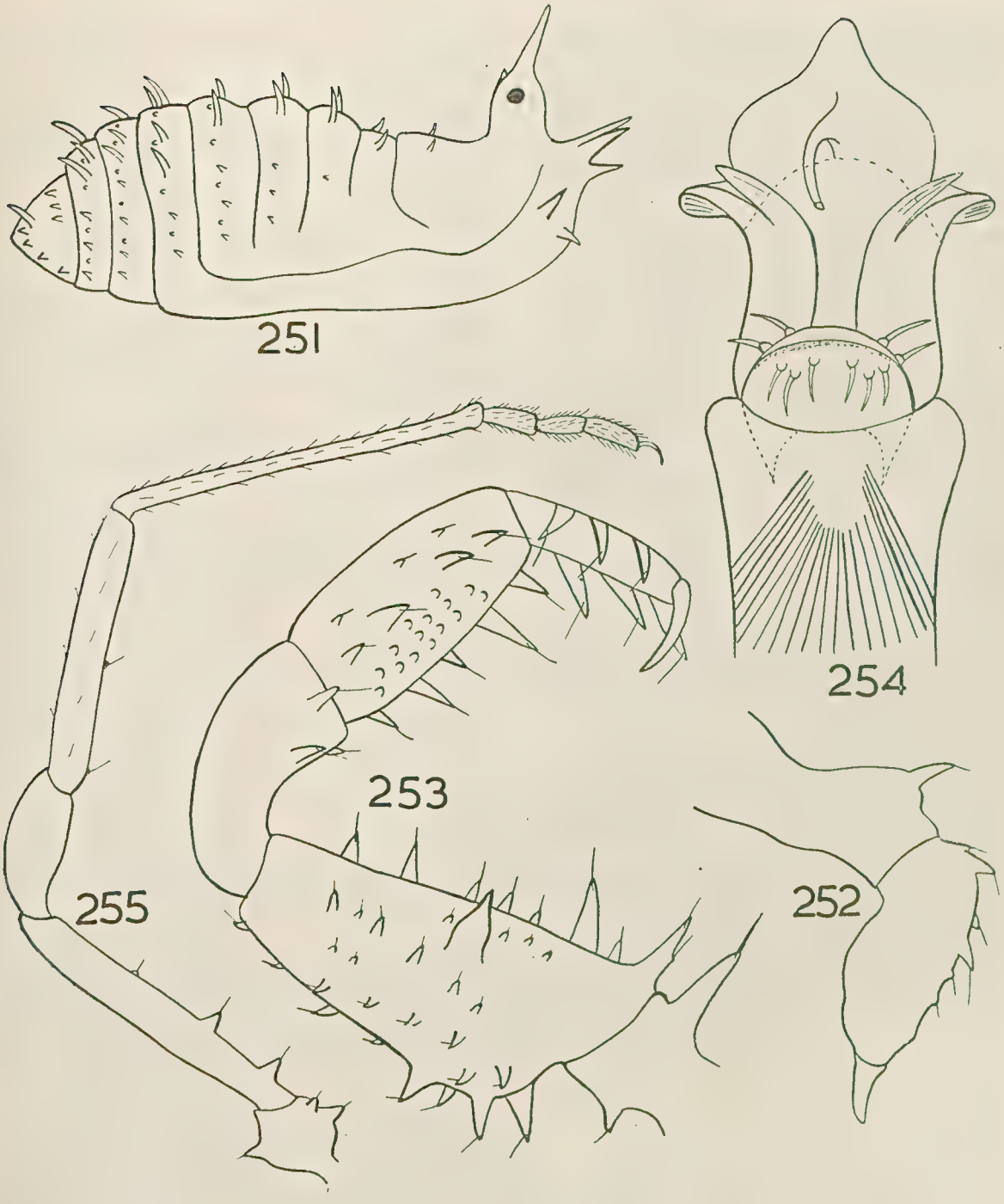
(Figures 251-255)

Holotype Male

Measurements in millimeters: Body-length 3·03, length of scutum 2·34, length of carapace 1·09.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·86	0·34	1·20	0·57	0·91	1·37	0·57	5·82
Leg 2	1·14	0·51	2·51	0·80	2·06	2·86	1·20	11·08
Leg 3	1·03	0·40	1·71	0·68	1·43	2·40	0·63	8·28
Leg 4	1·14	0·51	2·45	0·74	1·71	3·43	0·69	10·67
Pedipalp	0·57	0·46	1·66	1·14	1·20	....	0·97	6·00

Colour (in alcohol): Scutum yellowish with a large black patch on each side, an irregular longitudinal black line between the median spines, and black reticulations in the anterior corners. Eyemound black with dark reticulations in front of the base. Free tergites mainly black with yellow round the base of each spine. Pedipalpi yellowish with dark-brown at the sides of and below the femur and dark reticulations on the dorsal surface of femur, patella, tibia and tarsus. Chelicerae yellowish with dark markings. Ventral surface of body yellow but dark-brown towards the distal ends of the coxae and on the sternites.



Phanerobunus saxatilis sp. n.

FIG. 251.—Lateral view of scutum and free tergites of male.
FIG. 252.—Prolateral view of chelicera of male.
FIG. 253.—Prolateral view of pedipalpus of male.
FIG. 254.—Ventral view of distal part of penis.
FIG. 255.—Leg I of male.

Scutum finely granular. Anterior margin armed with four large spines on each side. Eyemound situated about its basal diameter from the front margin and surmounted by a long spine, which is inclined slightly forwards and has a small granule behind its base (fig. 251). Between the eyemound and the scutal groove is a median pair of short spines. The scutal groove and other tergal grooves are strongly marked. Tergal Areas I-IV are each furnished with a transverse row of spines, the median pair in each row being slender, erect and longer than the spines on each side. Area V and each free tergite are also provided with a transverse row of spines, each row having a median spine with about four others on each side. Between adjacent spines in the row is a small granule. The third free tergite has an anterior as well as a posterior row of small spinous tubercles.

Chelicerae (fig. 252) are small. The first segment is armed with a large dorsal spine near the apex. The second segment has two small spines and several tubercles on the dorsal surface.

Pedipalpi (fig. 253) large and strong. The femur is armed on the dorsal side with a median row of five teeth, of which the first is the largest. On the prodorsal margin is a row of six smaller teeth and on the retrodorsal margin a row of five granules. The prolateral surface is armed with a row of five teeth, below which is a large stout conical projection directed inwards and downwards. The ventral surface has a large median proximal tooth, a retromarginal row of seven teeth and, in the basal half, a promarginal row of small granules. The patella is armed with two large prolateral teeth. The tibia is tuberculate below and is armed with a prolateral row of four and a retrolateral row of five teeth. The tarsus has three teeth on each side.

Coxae are finely granular. Coxa I has two large promarginal teeth, the apical tooth being bifid. Coxa II is armed with one large and two small teeth behind the apex. Coxa III has a marginal row of granules in front and behind. Coxa IV is armed with one large and two small teeth in front of the apex and a row of granules on the posterior margin.

The genital operculum is somewhat triangular, rounded at the sides and bluntly pointed in front. The penis (fig. 254) is provided with an uncleft ventral plate, which has two pairs of superior and three pairs of inferior setae. The distal end of the glans is swollen and the male duct terminates in a ventral hook-like structure. On each side of the base of the glans is a wide lateral process, which has its distal end curved outwards and divided into two lobes ,the inner lobe being sharp and the outer lobe blunt.

The sternites are smooth. The respiratory spiracles are concealed under bridging granules on the posterior margin of the fourth coxae.

The legs are long and slender. They are unarmed and smooth except the femur of leg I (fig. 255), which has a row of two tubercles and two small granules on the ventral surface. The tibia also has two small ventral granules. All calcanei are small and weakly developed. The tarsal segmentation is 3, 6, 4, 4. Distitarsi I and II have two and three segments respectively. The claws of tarsi III and IV are three-pronged, the lateral prongs being smaller and weaker than the median prong.

Allotype Female

Measurements in millimeters: Body-length 3·36, length of scutum 2·34, length of carapace 1·03.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·74	0·34	1·08	0·57	0·91	1·26	0·57	5·47
Leg 2	1·14	0·45	2·40	0·74	2·11	2·74	1·14	10·72
Leg 3	1·03	0·40	1·83	0·68	1·48	2·34	0·51	8·27
Leg 4	1·20	0·51	2·51	0·80	1·77	3·43	0·68	10 90
Pedipalp	0·40	0·46	1·43	0·97	1·08	....	0·86	5·20

The female differs from the male in having much smaller pedipalpi, in lacking the large conical projection on the prolateral side of the femur of the pedipalpi and in the absence of tubercles below the tibia. Tarsal segmentation is the same as that of the male.

Localities: The type specimens were collected under stones at Fern Tree, Tasmania, 22nd February, 1945. The species also occurs at many other places on Mount Wellington.

Variations: The collection contains 12 males and 6 females. The males vary in body-length from 2·38-3·19 mm. and the females from 2·44-3·94 mm. All specimens have four segments in each of tarsi III and IV. The number of segments in tarsus II varies from six to nine as shown in Table 21.

Table 21

Number of specimens	Sex	Number of segments in tarsus I	Number of segments in tarsus II
8	♂	3	6
1	♂	3	6L 7R
1	♂	3	7L 6R
1	♂	3	8L 7R
1	♂	3	9L 8R
5	♀	3	6
1	♀	3	7

PHANEROBUNUS ASPERRIMUS sp. n.

(Figures 256-261)

Holotype Male

Measurements in millimeters: Body-length 2·86, length of scutum 2·28, length of carapace 1·14.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·63	0·34	1·20	0·57	0·86	1·14	0·63	5·37
Leg 2	1·14	0·42	2·11	0·74	1·71	2·17	1·20	9·49
Leg 3	1·03	0·40	1·48	0·63	1·26	1·94	0·63	7·37
Leg 4	1·26	0·46	2·00	0·69	1·71	2·80	0·68	9·60
Pedipalp	0·40	0·40	1·83	1·26	1·20	....	0·91	6·00

Colour (in alcohol): Scutum yellow with a large black region on each side and irregular black markings across the tergal Areas and around the margin. A yellow transverse line between Areas IV and V. Eyemound dark with black reticulations round the base. Free tergites black with yellowish margins. Spines on scutum and free tergites with yellow round the base. The chelicerae and pedipalpi yellowish brown with dark reticulations. Ventral

surface of body yellow with dark reticulations on the greater part of coxae I and IV and on the distal part of coxae II and III. Sternites black with yellowish margins and a transverse row of yellow spots. A median yellow stripe extends from the genital operculum to anus. Legs dark-brown but paler on trochanters, patellae and distal end of femora. A pale band on the distal half of tibiae III and IV.

Scutum (fig. 256) has a row of four spines on each side in front. Eyemound is situated about its basal diameter from the anterior margin, and is surmounted by a long spine, which is inclined forward and has a small posterior projection above the eyes (fig. 257). The carapace is furnished with several small granules behind the eyemound. Scutal groove and tergal grooves are well marked. Tergal Areas I-IV each with a transverse row of short conical spines, the median pair being larger than the lateral ones. Tergal Area V and free tergites I and II each with a transverse row of conical spines. Each row has a single median spine and about four lateral spines on each side. Free tergite III has a row of three or four small tubercles in front and several small tubercles on posterior margin.

Chelicerae are furnished with a prominent dorsal spine at the apex of the basal segment and three conical tubercles on the dorsal surface of the second segment.

Pedipalpi (fig. 258) are large and strong. The trochanter is armed with a tooth above and below, the ventral one being the larger. The femur has a mid-dorsal row of seven teeth and a prodorsal row of four smaller teeth. The prolateral surface has three teeth near the middle and one at the apex. Near the middle of the proventral margin is a large stout conical projection. The ventral surface is armed with a large proximal tooth, a proventral row of five small tubercles in the basal half and a retroventral row of seven teeth; of which the second, fourth and sixth are larger than the others. The retrolateral surface has a few small granules above the retroventral row of teeth. The patella has two prolateral teeth and a small retrolateral granule. The tibia is tuberculate below and has three prolateral and five retrolateral teeth. The tarsus has three teeth on each side.

Coxa I with two large teeth on anterior margin, the apical tooth being bifid. Several smaller conical tubercles are present on the ventral surface. Coxa II has a small tooth and two granules behind the apex. Coxa III with a marginal row of granules in front and behind. Coxa IV with a small tooth and several granules in front of the apex and a row of granules on posterior margin. The sternum has the form shown in fig. 259. Genital operculum somewhat triangular, rounded at the sides and wider than long. The penis has the form shown in fig. 260. The ventral plate is uncleft and has two pairs of superior and three pairs of inferior setae. The distal part of the glans has the form of a narrow tube, which lies between two sharp-pointed processes and is covered dorsally by a delicate hood with a serrate margin. The tube ends in a sharp point, which extends slightly beyond the aperture of the male duct. On each side of the base of the glans is a bilobed lateral process. The lobes are blunt and curved outwards.

The sternites are smooth and the respiratory spiracles hidden under the posterior margins of the fourth coxae.

The legs are slender. Leg 1 (fig. 261) has two conical tubercles below the basal half of the femur and a single ventral tubercle near the base of the tibia. The other legs are smooth and unarmed. Calcanei are small and weakly developed. All metatarsi show indistinct signs of pseudosegmentation. Tarsal segmentation: 3, 6, 4, 4. Distitarsi I and II with two and three segments respectively. Claws of legs III and IV are three-pronged, the lateral prongs being smaller and weaker than the median prong.

Allotype Female

Measurements in millimeters: Body-length 3·26, length of scutum 2·17, length of carapare 1·09.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·57	0·34	1·03	0·51	0·69	0·97	0·51	4·62
Leg 2	0·97	0·40	1·77	0·68	1·48	1·88	1·03	8·21
Leg 3	0·91	0·34	1·43	0·63	1·08	1·66	0·54	6·59
Leg 4	1·09	0·46	1·77	0·69	1·37	2·46	0·68	8·52
Pedipalp	0·34	0·34	1·26	0·86	0·91	....	0·74	4·45

The female resembles the male in colour and general features. It differs, however, in having much smaller pedipalpi, in lacking the large conical projection, which is present on the prolateral side of the femur of the male pedipalp and in the tibia being less tuberculate on the ventral surface. The genital operculum is wider in proportion to its length than in the male.

Localities: The holotype and allotype were found under decaying logs on Mt. Dromedary, Tasmania, 10th November, 1955. The harvestman also occurs on Mount Wellington, Mount Hobbs, Spring Hill and on the central plateau at Tarraleah, Bronte Park and regions near Great Lake. Besides occurring under decaying logs, it is also found under stones, in grass tussocks, and amongst the debris that collects at the base of tree-ferns.

Variations: The collection contains 21 males and 28 females. The males vary in body-length from 2·60-3·20 mm. and the females from 2·67-3·54 mm. The normal tarsal segmentation in both sexes is 3, 6, 4, 4. The number of segments in tarsus II varies from 5-8. All the specimens have four segments in each of tarsi III and IV. Much asymmetry is exhibited in the segmentation of tarsus II (see Table 22).

Table 22

Number of specimens	Sex	Number of segments in tarsus I	Number of segments in tarsus II
13	♂	3	6
1	♂	3	5L 6R
1	♂	3	6L 5R
2	♂	3	6L 7R
2	♂	3	7
1	♂	3	7L 6R
1	♂	3	7L 8R
19	♀	3	6
5	♀	3	5
3	♀	3	6L 5R
1	♀	3	6L 7R

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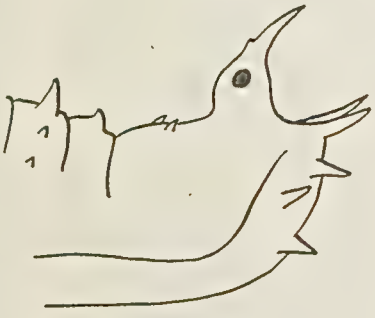

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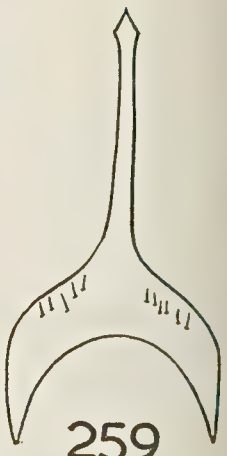

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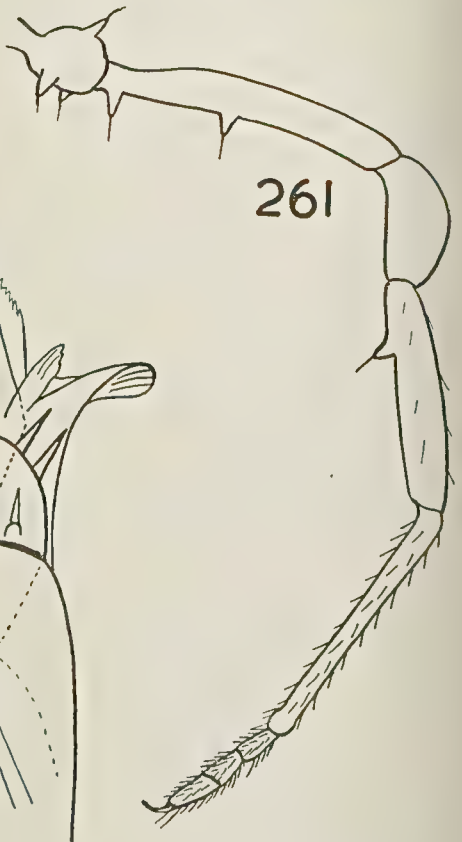

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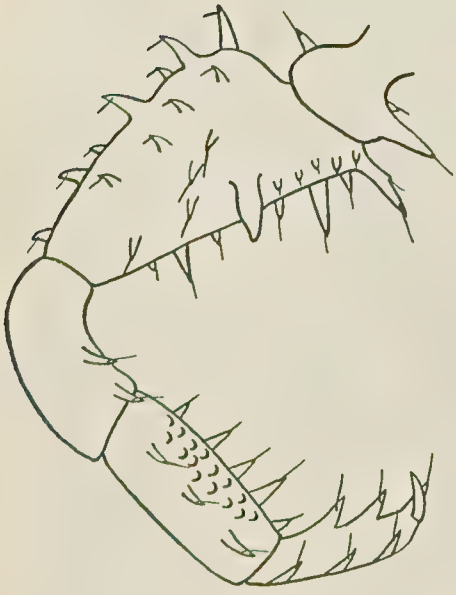

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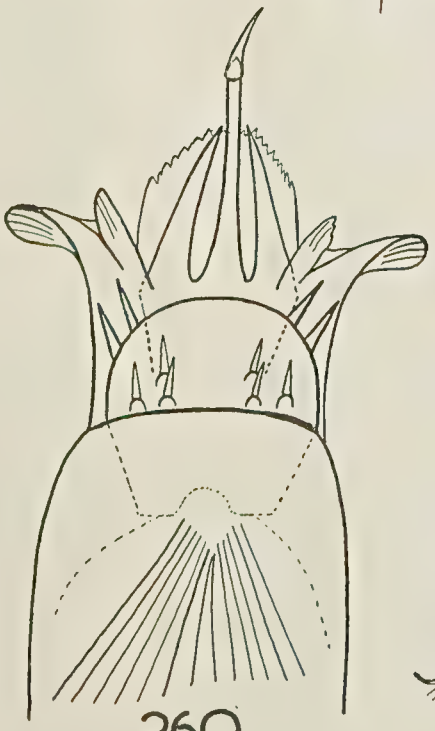

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Phanerobunus asperrimus sp. n.

FIG. 256.—Dorsal view of scutum and free tergites of male.
FIG. 257.—Lateral view of eyemound.
FIG. 258.—Prolateral view of pedipalpus of male.
FIG. 259.—Sternum of male.
FIG. 260.—Ventral view of distal part of penis.
FIG. 261.—Leg I of male.

PHANEROBUNUS HEBES sp. n.

(Figures 262-267)

Holotype Male

Measurements in millimeters: Body-length 3·26, length of scutum 2·68, length of carapace 1·26.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·80	0·40	1·43	0·63	1·03	1·43	0·57	6·29
Leg 2	1·26	0·46	2·57	0·80	2·17	2·57	1·14	10·97
Leg 3	1·08	0·46	1·71	0·74	1·43	2·34	0·63	8·39
Leg 4	1·31	0·48	2·17	0·74	1·60	3·48	0·74	10·52
Pedipalp	0·51	0·57	2·00	1·43	1·31	....	0·97	6·79

Colour (in alcohol): Scutum yellowish brown marked with black near the margin and with a large black area on each side. Eyemound black. Tergal grooves with a median dark mark. Areas IV and V separated by a transverse yellow line. Area V and the free tergites black with yellow round the base of each spine. Segments of pedipalpi yellow with dark reticulations above merging into black at the sides. Coxae yellow with dark reticulations towards the distal ends. Sternites yellow with a dark patch on each side and a pair of dark patches in the middle. Legs mainly brown.

Scutum (fig. 262) finely granular. Front margin with three teeth on the left side and three on the right. The two teeth in front of the eyemound are larger than the others. Eyemound (fig. 263) conical and surmounted by a long spine which is inclined slightly towards the front. The eyemound is situated about its basal diameter from the anterior margin. Several small granules are present on the carapace behind the eyemound. Scutal and tergal grooves are clearly defined. Tergal Area I has a single pair of median spines; Area II-IV a transverse row of four spines, of which the median pair are the largest. Area V and the free tergites each with a transverse row of spines, the median one being the largest. All spines are widely spaced and have blunt, somewhat truncated, ends.

Chelicerae are provided with a single apical spine on the dorsal surface of the first segment and with two teeth on the dorsal surface of the second segment, one near the base the other near the middle.

Pedipalpi (fig. 264) large and powerful, more than twice the length of the body. The trochanter has a small tooth above and a larger one below. The femur large and swollen; its greatest dorso-ventral diameter is equal to slightly more than half its length. The dorsal surface is furnished with a median row of five teeth, of which the first three are much larger than the others, and a promarginal row of four small teeth. The prolateral surface has an oblique row of four truncate teeth, below which is a large stout conical projection situated slightly above the middle of the proventral margin and directed inwards and downwards. On the ventral surface is a large proximal tooth, a promarginal row of five small denticles and a retromarginal row of six teeth, of which the second, fourth and sixth are larger than the others. The patella has two blunt prolateral teeth and a small retrolateral tubercle. The tibia is tuberculate below and has five teeth on each side. The tarsus has three teeth on each side.

Coxa I has two large teeth on the anterior margin, the apical tooth being bifid. A few smaller tubercles are present on the ventral surface. Coxa II has an apical tooth and several small tubercles on the posterior surface. Coxa III has a marginal row of granules in front and behind. Coxa IV has a small apical tooth in front and a row of marginal granules behind. The genital operculum is somewhat triangular, rounded at the sides and slightly wider than long. The penis has the form shown in fig. 266. The ventral plate has two pairs of superior and three pairs of inferior setae. The distal part of the glans is a narrow tube curved ventrally and covered by a hood-like structure, which is somewhat pointed in front and produced into two sharp spines on each side. A pair of lateral processes is situated on one each side at the base of the glans. Their extremities are bilobed and curve outwards. The sternum has the form shown in fig. 265. It is wide and crescentic at the posterior end and its anterior part long and narrow. The sternites are smooth and unarmed. The respiratory spiracles are concealed.

Legs are smooth and unarmed except in leg 1 (fig. 267) which has three small tubercles below the femur and two below the tibia. The calcanei are very small and poorly differentiated. All the metatarsi exhibit traces of pseudosegmentation. Tarsal segmentation: 3, 6, 4, 4. Distitarsi I and II with two and three segments respectively. The claws of legs III and IV are three-pronged, the middle prong being larger and stronger than the lateral prongs.

Allotype Female

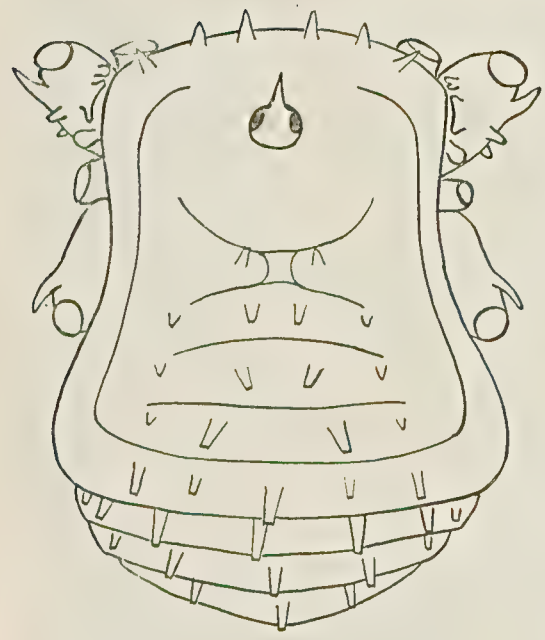
Measurements in millimeters: Body-length 3·48, length of scutum 2·46, length of carapace 1·08.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·57	0·31	1·14	0·51	0·96	1·14	0·57	5·10
Leg 2	1·03	0·40	2·17	0·68	1·77	2·23	1·14	9·42
Leg 3	1·02	0·40	1·49	0·63	1·26	2·05	0·57	7·42
Leg 4	1·14	0·51	2·05	0·74	1·48	2·80	0·74	9·46
Pedipalp	0·40	0·40	1·43	1·09	0·91	....	0·80	5·03

The female resembles the male in colour and general appearance. However, the pedipalpi are much smaller and lack the large conical projection on the prolateral side of the femur, its place being taken by an ordinary spine. The genital operculum is broadly triangular and wider in proportion to its length than in the male. Tarsal segmentation is the same as in the male.

Localities: The holotype and allotype were found at Eaglehawk Neck, Tasmania, 22nd August, 1951. The species also occurs at Highcroft. It is usually found under decaying logs.

Variations: Males vary in body-length from 2·38-3·26 mm. and females from 2·44-3·48 mm. Some examples have three spines on each side of the anterior margin of the carapace and others have four. The normal tarsal segmentation in both sexes is 3, 6, 4, 4. Eleven males and twelve females were examined. All had the normal tarsal segmentation except two of the males, in which the tarsi of the second pair of legs had seven segments on the left side and six on the right.



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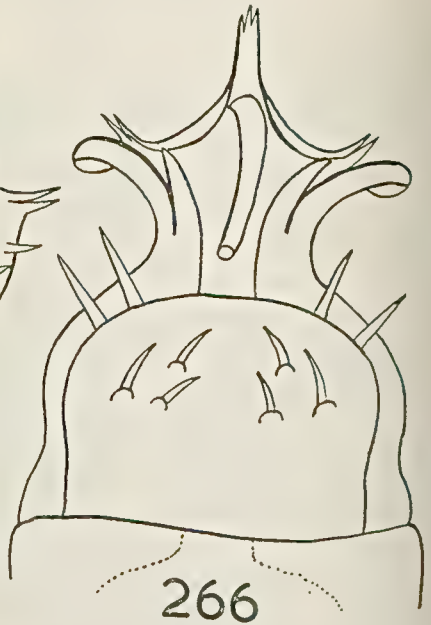

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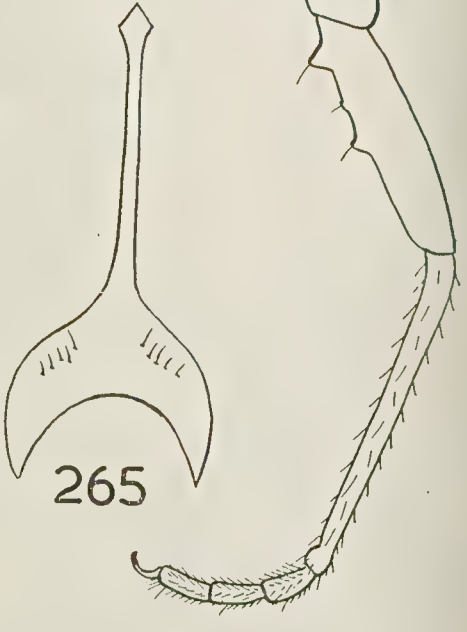

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Phanerobunus hebes sp. n.

FIG. 262.—Dorsal view of scutum and free tergites of male.
FIG. 263.—Lateral view of eyemound.
FIG. 264.—Prolateral view of pedipalpus of male.
FIG. 265.—Sternum of male.
FIG. 266.—Ventral view of distal part of penis.
FIG 267.—Leg I of male.

Genus MIOBUNUS Roewer, 1914

Anterior margin of scutum unarmed and not marked off by a transverse groove. Eyemound arising almost from the margin, ascending steeply in front and forming a sharp angle above but unarmed. The scutum has five distinct transverse grooves, which are not marked by a series of granules. Tergal Areas and free tergites without a median pair of projecting tubercles or spines. Respiratory spiracles concealed under bridging teeth on the posterior margin of the fourth coxae. Sternum wide and crescentic behind. Calcaneus of each metatarsus conical and about 1/7-1/9 the length of the astragalus. Tarsal segmentation: 3, 4, 4, 4. Distitarsi I and II with two and three segments respectively.

Genotype: *Miobunus thoracicus* Roewer.

Type Locality: Tasmania.

Hitherto the genotype, described by Roewer from a single male specimen, has been the sole representative of the genus, and there does not appear to be an example of it in the present collection. However, a new species, *Miobunus levis*, is described below and may be distinguished from *M. thoracicus* as follows:

Tergal Areas and free tergites each furnished with a transverse row of coarse tubercles ... *M. thoracicus* Roewer
Tergal Areas and free tergites not furnished with transverse rows of coarse tubercles .... *M. levis* sp. n.

MIOBUNUS LEVIS sp. n.

(Figures 268-271)

Holotype Male

Measurements in millimeters: Body-length 1·54, length of scutum 1·14, length of carapace 0·57.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·34	0·17	0·51	0·29	0·40	0·46	0·46	2·63
Leg 2	0·63	0·23	0·74	0·34	0·63	0·63	0·74	3·94
Leg 3	0·46	0·17	0·51	0·29	0·40	0·51	0·46	2·80
Leg 4	0·51	0·23	0·69	0·40	0·63	0·80	0·57	3·83
Pedipalp	0·23	0·23	0·57	0·40	0·40	....	0·34	2·17

Colour (in alcohol): Scutum light-brown with dark reticulations on each side of the carapace and round the base of the eyemound. A median light-brown saddle-shaped region is present on tergal Areas I and II. Behind and at the sides of the saddle-shaped region the scutum is dark-brown. Tergal Area V and the first two free tergites are light-brown with a transverse band of dark-brown. The third free tergite is dark-brown. Chelicerae, pedipalpi and coxae light-brown with faint dark reticulations. Free sternites dark-brown laterally and light-brown in the middle. Legs mainly dark-brown, the femora, patellae and tibiae being pale distally.

Scutum (fig. 268) shagreened. A small denticle is present on each side above the anterior margin. Eyemound unarmed, and broadly conical. In front it rises almost vertically from the margin of the scutum and ends in a blunt point at the apex. The scutal groove is distinct medianly. The other tergal grooves are not distinct. Tergal Areas and free tergites unarmed and without tubercles and granules.

Chelicerae moderately strong. The first segment is 0·34 mm. long and furnished with a short median dorsal apical spine. The second segment is 0·57 mm. long and provided with a row of three small tubercles on the prodorsal margin.

Pedipalpi (fig. 269) strong. The trochanter is armed with a small tooth above and a larger one below. The dorsal surface of the femur has a median row of four teeth. The retrolateral side is furnished with a small tubercle above the middle of the retroventral margin. The prolateral side has a row of three teeth. The ventral surface is armed with a large median proximal tooth and a row of three smaller teeth on both the retromargin and promargin. The first tooth in each row being larger than the other two. The patella has two small blunt prolateral tubercles. The tibia is tuberculate below and furnished with two prolateral and three retrolateral teeth. The tarsus has three teeth on each side. The claw is about half the length of the segment.

Coxae shagreened. Coxa I has three small promarginal teeth, the distal tooth being bifid. Coxa II is armed with a large conical tooth behind the apex and a broad tubercle above. Coxa III has a marginal row of granules in front and behind. Coxa IV is without spines and tubercles in front of the apex but has a row of granules on the posterior margin. The distal granule is large and extends over the respiratory spiracle.

The genital operculum measures 0·23 mm. long and 0·25 mm. wide. It is smooth and rounded in front. The sternum (fig. 270) is somewhat longer than is usual in members of the subfamily but is wide and crescentic behind. The respiratory spiracles are concealed under bridging granules on the fourth coxae.

Legs are unarmed but the first pair (fig. 271) have a few coarse tubercles below the femur and three below the tibia. All calcanei are conical, straight and much shorter than the astragali. The number of segments in tarsi I-IV is 3, 4, 4, 4. Distitarsi I and II each have two segments. The claws of tarsi III and IV are three-pronged, the median prong being larger than the lateral prongs.

Allotype Female

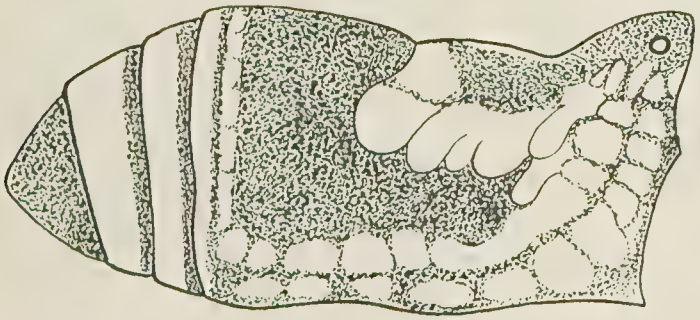
Measurements in millimeters: Body-length 1·71, length of scutum 1·20, length of carapace 0·63.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·29	0·17	0·51	0·29	0·37	0·40	0·40	2·43
Leg 2	0·57	0·23	0·69	0·29	0·57	0·63	0·80	3·78
Leg 3	0·40	0·17	0·51	0·25	0·46	0·51	0·46	2·76
Leg 4	0·51	0·25	0·63	0·31	0·63	0·74	0·57	3·64
Pedipalp	0·23	0·20	0·46	0·29	0·34	....	0·29	1·81

The female resembles the male in general appearance, but the saddle-shaped region on the scutum is smaller and the pedipalpi less robust. The genital operculum is 0·25 mm. long and 0·29 mm. wide. Tarsal segmentation as in the male.

Locality: The type specimens and two other specimens, both females, were found amongst fallen leaves at the side of a moss-covered log at Tarraleah, Tasmania, December, 1952.

Variations: The three females varied in body-length from 1·62-1·74 mm. No variation in the number of segments in the tarsi was exhibited by the four specimens and all had two segments in both distitarsi I and II.



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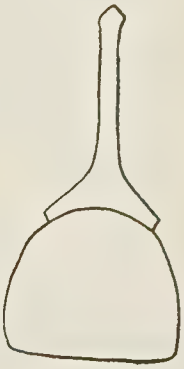

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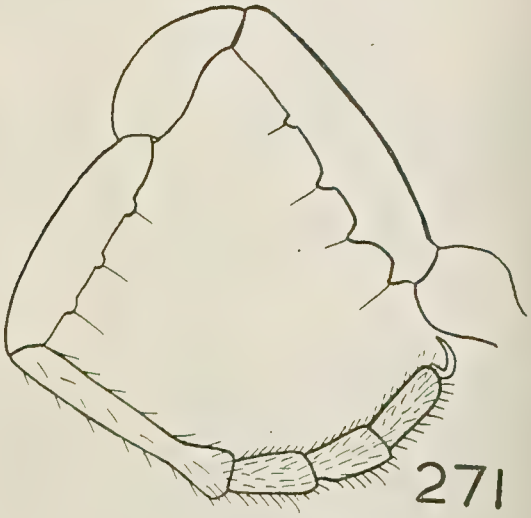

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Miobunus levis sp. n.

Fig. 268.—Lateral view of scutum and free tergites of male.
Fig. 269.—Retrolateral view of pedipalpus of male.
Fig. 270.—Sternum and genital operculum of male.
Fig. 271.—Leg I of male.

Genus TASMANOBUNUS gen. n.

Eyemound unarmed, conical and rising directly from the middle of the anterior margin. Carapace without spines but with a small tubercle on each side above the front margin. Each tergal Area and free tergite with a transverse row of small tubercles but without spines. Posterior end of sternum wide and crescentic. Genital operculum smooth. Respiratory spiracles partly concealed by bridging teeth on the fourth coxae. Leg I with a few ventral tubercles; other legs smooth and unarmed. Calcanei short and knob-like. Tarsal segmentation: 3, 5, 4, 4. Distitarsi I and II with two and three segments respectively. Claws of tarsi III and IV three-pronged, the middle prong being larger than the lateral prongs.

Genotype: *Tasmanobunus constans* sp. n.

Type Locality: Mount Wellington, Tasmania.

The genus *Tasmanobunus* is close to *Miobunus* Roewer, but differs in the segmentation of the second tarsi. There is also some resemblance to the New Zealand genus *Psalenoba*, which Roewer (1931, p. 159) places in the subfamily Triaenonychinae.

TASMANOBUNUS CONSTANS sp. n.

(Figures 272-276)

Holotype Male

Measurements in millimeters: Body-length 2·11, length of scutum 1·77, length of carapace 0·86.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·57	0·25	0·80	0·40	0·57	0·74	0·51	3·84
Leg 2	0·80	0·29	1·20	0·51	0·97	1·14	0·91	5·82
Leg 3	0·68	0·28	0·74	0·46	0·69	0·86	0·57	4·28
Leg 4	0·80	0·34	1·03	0·46	0·94	1·20	0·63	5·40
Pedipalp	0·29	0·23	1·03	0·57	0·63	....	0·57	3·32

Colour (in alcohol): Carapace orange with brown reticulations. Tergal region orange with a median brown stripe crossed by four transverse brown bars situated between the tergal Areas. On each side the brown bars merge in a large lateral brownish region, below which is a row of large orange spots. Chelicerae orange with brown reticulations. Pedipalpi orange with brown reticulations, except on the distal part of the femur, the patella, the distal third of the tibia and the basal half of the tarsus, which are orange without dark markings. Coxae, sternum and genital operculum orange. Free tergites yellow, the second and third marked with brown anteriorly. Each sternite is dark-brown anteriorly and orange posteriorly. A median yellow band extends from the genital operculum to the anus.

Scutum finely granular and without spines. A minute tubercle is situated on each side of the anterior margin above the base of each pedipalpus. Eyemound low, broadly conical, pointed and rising almost vertically from the front margin (fig. 272). Scutal groove and tergal grooves distinct and extending laterally. Each tergal Area and free tergite provided with a transverse row of minute tubercles, which are seen most clearly in dry specimens.

Chelicerae (fig. 273) moderately strong. Basal segment 0·51 mm. long, second segment 0·80 mm. long. The first segment is armed with a short median apical spine. The second segment has three retrodorsal tubercles and three prodorsal teeth, of which the middle one is larger than the others.

Pedipalpi (fig. 274) are large and powerful. The trochanter is armed with a ventral tooth. The femur has a mid-dorsal row of four small teeth in the basal half continuous with a row of four granules in the apical half. There is also a prodorsal row of four teeth and a single prolateral tooth. On the ventral side there is a large proximal tooth, a proventral row of five granules and a retroventral row of one large proximal tooth, two much smaller teeth and a granule. The patella has two prolateral teeth. The tibia has two prolateral and three retrolateral teeth. The tarsus has three teeth on each side.

Coxa I has a row of three promarginal teeth, the middle tooth being the largest and the apical one slightly bifid. Behind the promarginal teeth are a few small tubercles. Coxa II has three small tubercles behind the apex. Coxa III is furnished with a marginal row of granules in front and behind. Coxa IV is without teeth or tubercles in front of the apex, but has a marginal row of granules behind.

The sternum (fig. 275) is somewhat elongate but wide and crescentic posteriorly. The genital operculum is smooth and rounded in front. It measures 0·31 mm. long and 0·34 mm. wide. The penis (fig. 276) is provided with a large uncleft ventral plate, which has three pairs of superior and three pairs of inferior setae. On each side of the ventral plate is a leaf-like lateral process, which in the fully extended condition is curved backwards. The distal part of the penis is wide and has two somewhat spatulate setae which project forwards. On the dorsal side about half way between the basal plate and the distal end is a pair of blade-like dorsal processes, which stand erect when fully extended. In the partly extended condition they lie close against the dorsal surface of the penis.

The respiratory spiracles lie close against the posterior margin of the fourth coxae and are partially concealed. The free sternites are smooth and without tubercles.

The legs are smooth and unarmed, except leg I which has two ventral tubercles on the proximal half of the femur. Each calcaneus is short and knob-like. The number of segments in tarsi I-IV is 3, 5, 4, 4. The claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

Allotype Female

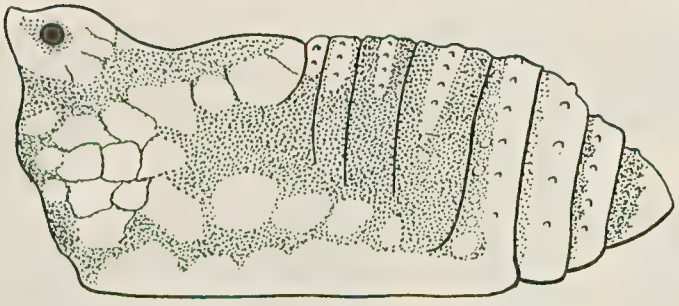
Measurements in millimeters: Body-length 2·23, length of scutum 1·71, length of carapace 0·80.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·65	0·23	0·63	0·40	0·46	0·57	0·45	3·39
Leg 2	0·80	0·28	0·97	0·46	0·80	0·91	0·80	5·02
Leg 3	0·63	0·23	0·68	0·34	0·57	0·74	0·51	3·70
Leg 4	0·68	0·29	0·91	0·51	0·86	1·08	0·57	3·90
Pedipalp	0·25	0·23	0·63	0·46	0·40	....	0·46	2·43

The female resembles the male in colouration, markings and general appearance. The pedipalpi, however, are shorter and less robust than those of the male. The genital operculum measures 0·25 mm. long and 0·34 mm. wide. The tarsal segmentation is the same as that of the male.

Locality: The holotype and allotype were found on Mount Wellington by J. L. Hickman, 15th May, 1956. The species also occurs at Weldborough, Bronte Park, and Highcroft. It is found in moss and also under decaying logs.

Variations: Males vary in body-length from 1·62-2·20 mm. and females from 1·62-2·55 mm. Over fifty specimens have been examined. In all of them the tarsal segmentation was 3, 5, 4, 4.



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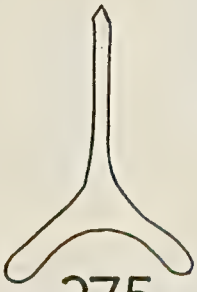

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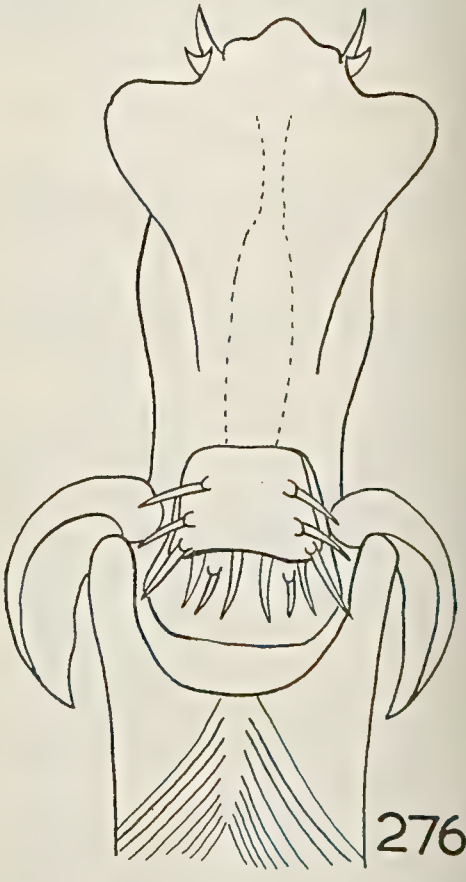

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Tasmanobunus constans gen. et sp. n.

Fig. 272.—Lateral view of scutum and free tergites of male.
Fig. 273.—Retrolateral view of chelicera of male.
Fig. 274.—Retrolateral view of pedipalpus of male.
Fig. 275.—Sternum of male.
Fig. 276.—Ventral view of distal part of penis.

TASMANOBUNUS PARVUS sp. n.

(Figures 277-282)

Holotype Male

Measurements in millimeters: Body-length 1·62, length of scutum 1·22, length of carapace 0·70.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·41	0·18	0·56	0·30	0·44	0·51	0·48	2·88
Leg 2	0·55	0·23	0·81	0·33	0·67	0·72	0·79	4·10
Leg 3	0·46	0·19	0·56	0·29	0·48	0·59	0·45	3·02
Leg 4	0·52	0·25	0·75	0·35	0·66	0·89	0·55	3·97
Pedipalp	0·22	0·15	0·64	0·41	0·37	....	0·37	2·16

Colour (in alcohol): Body and appendages yellow. Scutum with a saddle-shaped area on the posterior half faintly outlined in brown. Tergites dark-yellow.

Scutum (fig. 277) finely granular. A small denticle is situated on each side above the anterior margin and about midway between the eyemound and the lateral angle. The eyemound, which is conical and rounded at the apex, rises from the middle of the front margin of the carapace. Scutal groove distinct medianly. The tergal grooves indistinct. A median pair of minute tubercles on Areas I-IV and a transverse row of minute tubercles on Area V and each free tergite.

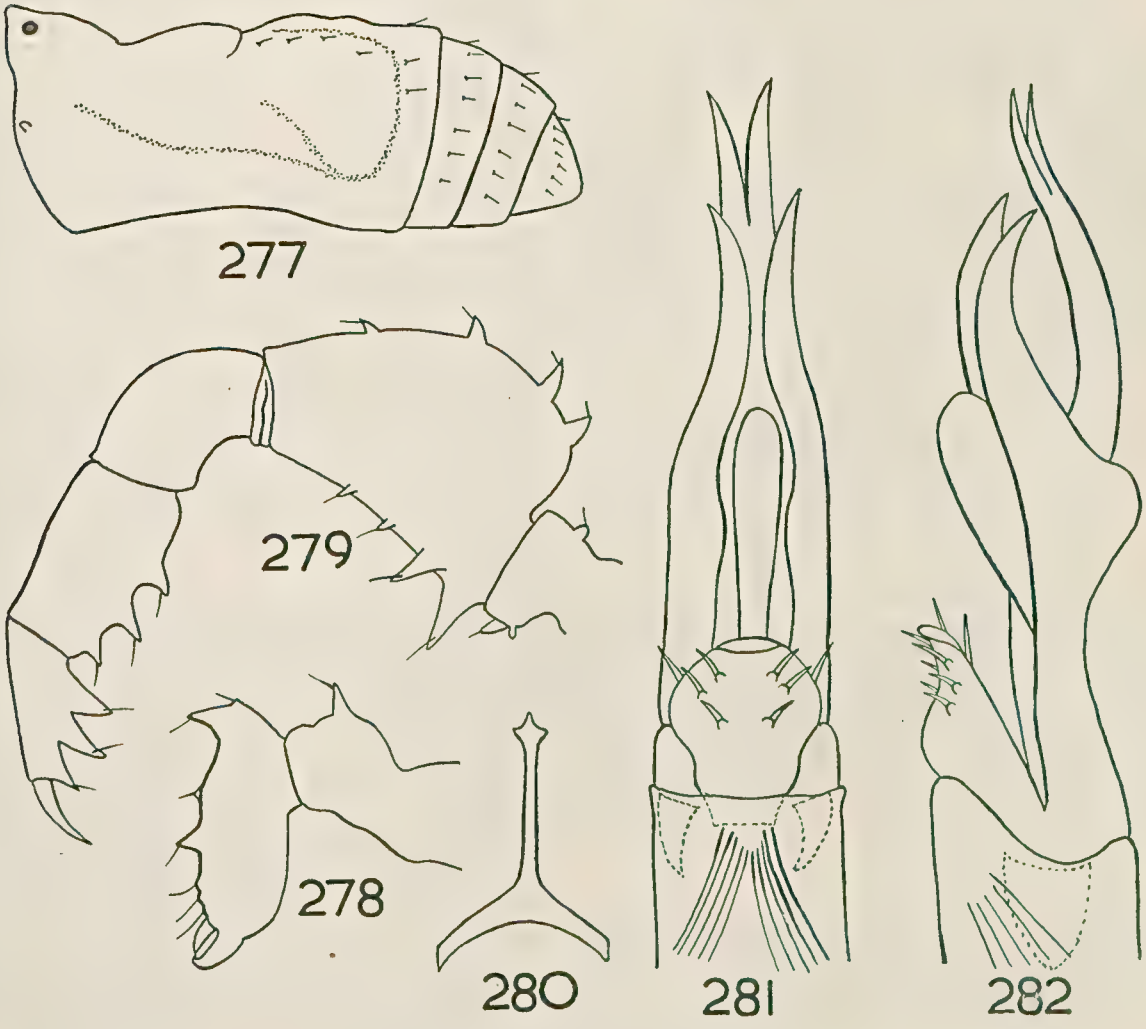
Chelicerae (fig. 278) armed with a median apical spine above the basal segment and with two large promarginal and a smaller retromarginal tubercle on the dorsal side of the second segment. Length of the basal segment is 0·41 mm., that of the second segment 0·60 mm.

Pedipalpi (fig. 279) large. The trochanter with a small tubercle above and a larger tooth below. Femur with a dorsal row of four teeth, two prodorsal teeth and two prolateral teeth. The ventral surface has a large basiventral tooth and a retro-

ventral row of three teeth, the proximal one being much larger than the other two. Patella has two prolateral teeth. Tibia has two prolateral and three retrolateral teeth, and a few tubercles on the ventral surface. Tarsus has three teeth on each side and a long claw.

Coxa I has a promarginal row of three tubercles, the apical one being bifid. Coxa II is provided with three tubercles behind the apex. Coxa III has a marginal row of granules in front and behind. Coxa IV has a small tubercle in front of the apex and a row of granules on the posterior margin. The sternum (fig. 280) is wide and crescent-shaped posteriorly.

Genital operculum is smooth, rounded in front, and measures 0·23 mm. wide and 0·23 mm. long. The penis has the form shown in figs. 281 and 282. The genital duct ends in a club-shaped structure, from the dorsal side of which a curved median bifid process projects forward. On each side the glans is protected by a long curved sickel-shaped process. The ventral plate is broad and not cleft. It is furnished with three pairs of inferior setae and one pair of superior setae. Below the basal plate and on each side there is a short curved leaf-like lateral process. However, owing to the penis not being fully extended, the processes cannot be clearly seen.



Tasmanobunus parvus gen. et sp. n.

Fig. 277.—Lateral view of scutum and free tergites of male.
Fig. 278.—Prolateral view of chelicera of male.
Fig. 279.—Retrolateral view of pedipalpus of male.
Fig. 280.—Sternum of male.
Fig. 281.—Ventral view of distal part of penis.
Fig. 282.—Lateral view of distal part of penis.

The respiratory spiracles are partially hidden by the posterior margins of the fourth coxae. The sternites are smooth.

The legs are smooth and unarmed, except for a row of four small tubercles below the femora of the first pair. Calcanei small and knob-like, much shorter than the astragali. Tarsal segmentation: 3, 5, 4, 4. Distitarsi I and II with two and three segments respectively. Claws of tarsi III and IV three-pronged, the lateral prongs being smaller and weaker than the median prong.

Allotype Female

Measurements in millimeters: Body-length 1·49, length of scutum 1·14, length of carapace 0·57.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·40	0·15	0·52	0·29	0·38	0·42	0·41	2·57
Leg 2	0·51	0·19	0·69	0·33	0·57	0·62	0·70	3·61
Leg 3	0·45	0·19	0·48	0·27	0·42	0·52	0·41	2·74
Leg 4	0·51	0·22	0·69	0·34	0·59	0·81	0·48	3·64
Pedi-palp	0·19	0·18	0·48	0·32	0·30	....	0·33	1·80

The female resembles the male in colouration and general appearance but lacks the saddle-shaped mark on the scutum. The pedipalpi are smaller and the tubercles below the femora of the first pair of legs are somewhat larger than in the male. The tarsal segmentation of both sexes is the same.

Localities: The type specimens were found among fallen leaves in *Notofagus* forest near Liffey Falls, Tasmania, 9th February, 1947. The species also occurs at Western Creek.

Variations: The collection contains 14 males and 18 females. The males vary in body-length from 1·22-1·56 mm. and the females from 1·04-1·80 mm. With the exception of one abnormal specimen all have the same tarsal segmentation: 3, 5, 4, 4. The abnormal specimen has only two segments in tarsus III on the left side.

Genus CHRESTOBUNUS Roewer, 1914

Eyemound rising from the anterior margin of the carapace, conical and pointed but unarmed. Scutum and free tergites without spines. Legs smooth except for a few tubercles below the femur and tibia of leg 1. Calcanei much shorter than astragali. Tarsal segmentation usually 3, 6, 4, 4. Distitarsi I and II with two and three segments respectively. Claws of tarsi III and IV three-pronged, the middle prong being larger than the lateral prongs.

Genotype: *Chrestobunus spinulatus* Roewer.

Type Locality: Tasmania.

The genus *Chrestobunus* contains only the genotype and one other species, *C. inermis* Roewer, both from Tasmania. A new species *C. fuscus* is described in the prseent paper. The three may be distinguished by the following key.

CHRESTOBUNUS FUSCUS sp. n.

(Figures 283-289)

Holotype Male

Measurements in millimeters: Body-length 1·88, length of scutum 1·48, length of carapace 0·80.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·40	0·19	0·69	0·34	0·51	0·54	0·51	3·18
Leg 2	0·57	0·23	1·02	0·40	0·80	0·97	0·91	4·90
Leg 3	0·51	0·23	0·69	0·30	0·57	0·69	0·48	3·47
Leg 4	0·57	0·25	0·90	0·46	0·74	1·08	0·51	4·51
Pedi-palp	0·28	0·29	0·69	0·40	0·51	....	0·46	2·63

Colour (in alcohol): Carapace yellowish brown with dark reticulations. The rest of scutum and the free tergites dark-brown. Chelicerae and pedipalpi reddish-brown with dark reticulations. Legs dark-brown with distal part of femora, patellae and tibiae yellowish. Ventral surface of coxae yellowish-brown with dark reticulations. Sternites dark-brown. Surface of body and the appendages matt, except chelicerae, pedipalpi and coxae I, which are polished.

Scutum (fig. 283) has a transverse row of three small tubercles on each side above the anterior margin. The eyemound is conical and in front rises almost vertically from the anterior margin. The apex is pointed but unarmed. With the exception of the groove between tergal Areas IV and V, which extends laterally, the scutal groove and tergal grooves are restricted to the median region. Tergal Areas I-IV each furnished with a median pair of small tubercles. Area V and the free tergites each with a transverse row of small tubercles, one tubercle in each row being median.

Chelicerae stout. The first segment measures 0·40 mm. in length and bulges dorsally in the distal half. It has a small median tubercle at the apex. The second segment measures 0·68 mm. long and has a median row of three small tubercles on the dorsal surface.

Pedipalpi (fig. 284) longer than body. Trochanter with a small tooth above and a larger spine below. On the dorsal surface the femur has a median row of five teeth, the fifth tooth being smaller than the others and situated at the apex. A single large tooth is present near the middle of the prodorsal margin and two teeth in the distal half of the prolateral surface. The retrolateral surface is unarmed. The ventral surface has a large median proximal tooth and a retroventral row of four, the first being the largest. The patella is armed with two prolateral spines. The tibia has four teeth on each side, the second and third tooth in each row being larger than the first and fourth. The tarsus has four prolateral and three retrolateral teeth. The claw is long, being about half the length of the segment.

Coxa I is furnished with a promarginal row of three tubercles, the distal one being bifid. Coxa II has a small tooth behind the apex and a wide

KEY TO SPECIES IN GENUS *CHRESTOBUNUS*

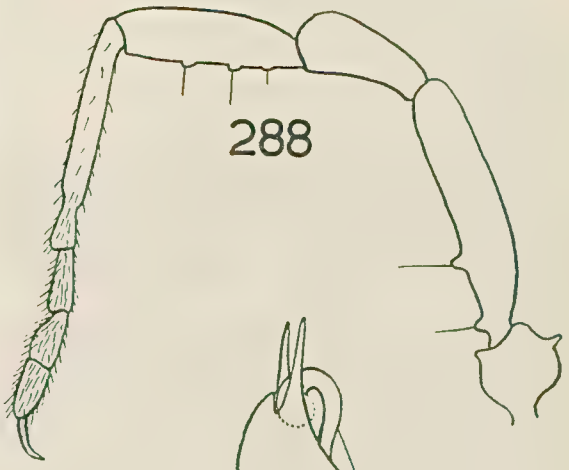
1. A proximal median spine below femur of pedipalp .... *C. fuscus* sp. n.
   No median spine below femur pedipalp 2
2. Tergal Areas I-IV with a median pair of granules .... *C. spinulatus* Roewer
   Tergal Areas I-IV without a median pair of granules .... *C. inermis* Roewer

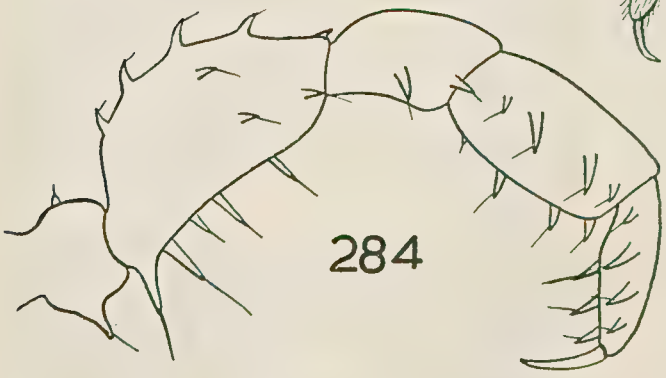
tubercle above. Coxa III is furnished with a marginal row of granules in front and behind. Coxa IV is devoid of tubercles in front but has a marginal row of granules behind.

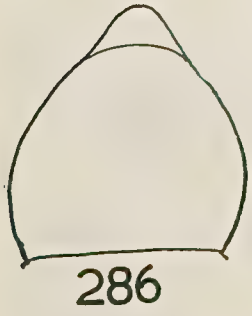
The sternum is wide and crescentic posteriorly (fig. 285). The genital operculum is smooth and somewhat pointed in front (fig. 286). It measures 0·31 mm. long and 0·29 mm. wide. The penis has the form shown in fig. 287. The ventral plate is provided with three pairs of inferior setae and three pairs of long lateral setae. The plate appears to be narrow and uncleft. The termination of the male duct is partly enclosed by a large hood-like structure which ends distally in two points. Above the hood-like structure is a shorter bifid dorsal process. On each side of the base of the glans there is a short curved lateral process.

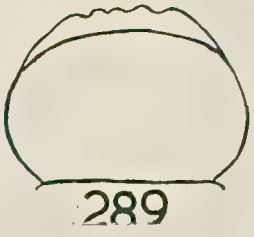
The respiratory spiracles are concealed under the posterior margin of the fourth coxae.

The legs are devoid of spines. Trochanters I and II each have a small conical tubercle above. Leg 1 (fig. 288) has two ventral tubercles on the









Chrestobunus fuscus sp. n.

FIG. 283.—Lateral view of scutum and free tergites of male.
FIG. 284.—Prolateral view of pedipalpus of male.
FIG. 285.—Sternum of male.
FIG. 286.—Genital operculum of male.
FIG. 287.—Lateral view of distal part of penis.
FIG. 288.—Leg I of male.
FIG. 289.—Genital operculum of female.

proximal half of the femur and three on the tibia. All the calcanei are short, straight and conical; that of leg 1 is about one-fifth the length of the metatarsus. Tarsal segmentation: 3, 6, 4, 4. Distitarsi I and II have two and three segments respectively. The claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

Allotype Female

Measurements in millimeters: Body-length 1·94, length of scutum 1·59, length of carapace 0·91.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·40	0·23	0·63	0·34	0·51	0·57	0·40	3·08
Leg 2	0·63	0·27	0·91	0·40	0·74	0·91	0·86	4·72
Leg 3	0·57	0·23	0·63	0·31	0·54	0·69	0·40	3·37
Leg 4	0·68	0·29	0·86	0·46	0·74	1·08	0·51	4·62
Pedipalp	0·23	0·28	0·69	0·40	0·46	....	0·40	2·46

The female closely resembles the male in size, form and colour. The femur of leg 1, however, is more tuberculate in the female than in the male. The genital operculum has a slightly crenulate anterior margin (fig. 289) and measures 0·23 mm. long and 0·29 mm. wide. The form of the operculum affords the most reliable means of distinguishing the sexes.

Localities: The type specimens were collected on Mount Wellington, Tasmania, 24th November, 1951. The species also is found in the Arve Forest at Geeveston. It occurs in moss and leaf mould.

Variations: The species is common and ninety-five specimens have been examined. Males vary in length from 1·57-2·15 and females from 1·57-2·20 mm. The tarsal segmentation, 3, 6, 4, 4, is reasonably stable. Only seven out of the ninety-five specimens departed from the normal condition, and these were asymmetrical specimens which exhibited a veriation in the number of segments in tarsus II, as is shown in Table 23.

Table 23

Number of specimens	Sex	Number of segments in tarsus I	Number of segments in tarsus II
41	♂	3	6
1	♂	3	4L 6R
1	♂	3	6L 5R
47	♀	3	6
1	♀	3	4L 6R
2	♀	3	5L 6R
1	♀	3	6L 7R
1	♀	3	7L 6R

Genus THELBUNUS gen. n.

Scutum and free tergites unarmed. Eyemound low, conical, unarmed and set back from the anterior margin. A transverse row of small rounded tubercles is present on tergal Areas II-V and on each free tergite. Sternum short and widely crescentic posteriorly. Respiratory spiracles not concealed. Legs unarmed. Each calcaneus conical, straight and much shorter than the astragalus. Number of segments in tarsi I-IV in the male 4, 9-11, 4, 4, and in the female 3, 9-10, 4, 4. The distitarsi I and II have two and three segments respectively. The claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

Genotype: *Thelbunus mirabilis* sp. n.

Type Locality: Weldborough, Tasmania.

THELBUNUS MIRABILIS sp. n.

(Figures 290-296)

Holotype Male

Measurements in millimeters: Body-length 3·77, length of scutum 2·84, length of carapace 1·45.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·97	0·51	1·39	0·64	1·04	1·33	0·93	6·81
Leg 2	1·31	0·54	1·91	0·75	1·57	1·97	1·91	9·96
Leg 3	1·03	0·46	1·39	0·64	1·16	1·57	1·04	7·29
Leg 4	1·37	0·57	1·80	0·81	1·57	2·38	1·22	9·72
Pedipalp	0·57	0·57	1·28	0·99	1·16	....	0·99	5·56

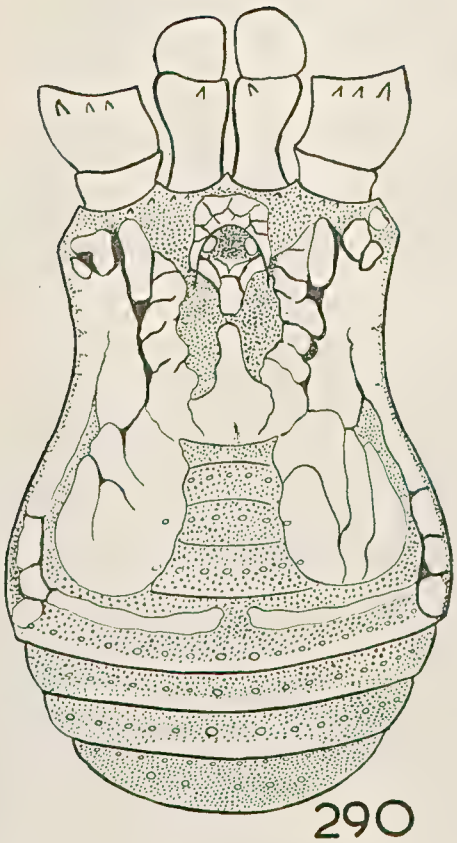
Colour (in alcohol): Dorsal surface of body with a reddish-brown saddle-shaped area on the scutum and dark-brown markings as shown in fig. 290. Eyemound black at the apex and with dark reticulations in front and behind. Chelicerae and pedipalpi reddish-brown with black reticulations. Legs reddish-brown with dark-brown bands on femora, tibiae and metatarsi. Coxae yellowish with dark reticulations. A pair of large oval yellowish areas on sternites II and III. Free sternites brownish.

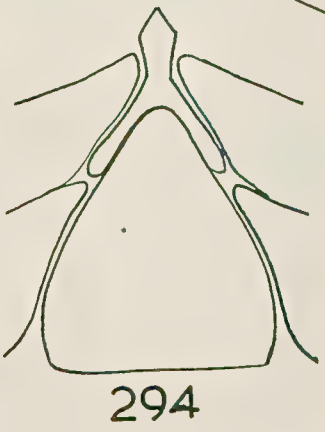
Scutum is unarmed but has a row of four small denticles on each side above the anterior margin. Eyemound low, conical and unarmed. It is set back from the front margin a distance about equal to its diameter and rises steeply in front sloping gently downwards behind. The first four tergal grooves are shallow and confined to the median region. The fifth groove is more strongly marked and extends laterally. Tergal Areas II-V and each free tergite furnished with a transverse row of small rounded tubercles.

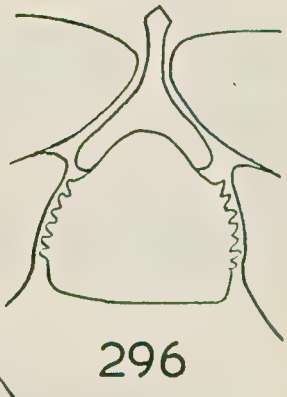
Chelicerae (fig. 291) strong. The first segment is 0·91 mm. long and is furnished with a small tooth on the dorsal side near the apex. The second segment is 1·37 mm. long. It has a rounded tubercle in the middle of the dorsal surface and distal to the tubercle a large tooth. On the posterior (or ventral) surface of the segment there is also a large curved tooth.

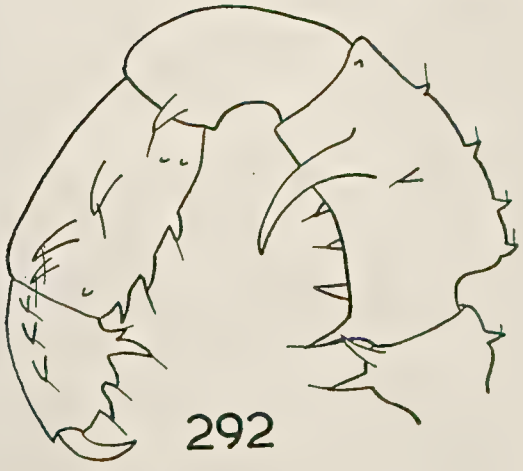
Pedipalpi (fig. 292) large and strong. The trochanter is armed with a row of three small spinous tubercles above, a much larger spine below and a large prolateral spine, which projects forwards. On the dorsal surface the femur is armed with a median row of four small teeth. On the prolateral side in the distal half there is a very large curved spine and a small tooth. On the ventral surface there is a large median proximal tooth and a retroventral row of three teeth, the first being the largest. The patella has on the prolateral side a conical tooth at the apex and a blunt tubercle near the middle. The retrolateral surface is unarmed. The tibia has three teeth on each side. The tarsus has three teeth on each side, the first tooth on the retrolateral side being large and bifid. Claw is long and curved.

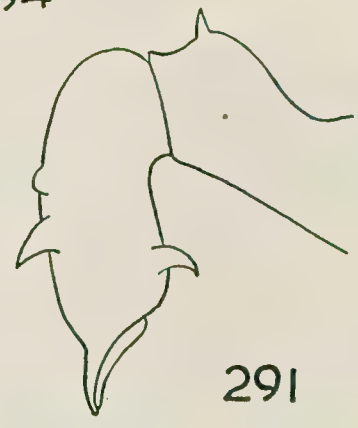
Coxa I (fig. 293) has a large bulge near the middle of the promargin and a bifid tooth at the apex.











Thelbunus mirabilis gen. et sp. n.

FIG. 290.—Dorsal view of scutum and free tergites of male.
FIG. 291.—Prolateral view of chelicera of male.
FIG. 292.—Prolateral view of pedipalpus of male.
FIG. 292.—Ventral view of right coxa I of male.
FIG. 294.—Sternum and genital operculum of male.
FIG. 295.—Ventral view of right coxae I and II of female.
FIG. 296.—Sternum and genital operculum of female.

Behind the bulge on the promargin is a large compressed tubercle, which rises vertically from the ventral surface of the coxa in the form of a small semicircular flange. Coxa II has a few tubercles behind the apex. Coxa III is furnished with a marginal row of granules in front and behind. Coxa IV has a few tubercles in front of the apex and a row of granules on the posterior margin.

The sternum (fig. 294) is very short and widely crescentic behind. The genital operculum is very large, bluntly pointed in front, strongly convex, and rebordered at the apex. The surface and margin are smooth. It measures 0·87 mm. in length and breadth.

The respiratory spiracles are small and round. They are situated a short distance behind the fourth coxae and are not concealed.

The legs are unarmed but the femora somewhat tuberculate below. All calcanei are short, conical and straight, being much shorter than the astragali. The number of segments in tarsi I-IV is 4, 11, 4, 4. Distitarsi I and II have two and three segments respectively. The claws of tarsi III and IV are three-pronged, the middle prong being larger than the lateral prongs.

Allotype Female

Measurements in millimeters: Body-length 3·94, length of scutum 2·86, length of carapace 1·43.

	Cox.	Troch.	Fem.	Pat.	Tib.	Met.	Tars.	Total
Leg 1	0·69	0·40	1·31	0·63	1·03	1·26	0·91	6·23
Leg 2	1·37	0·51	1·94	0·80	1·60	1·88	2·00	10·10
Leg 3	1·03	0·40	1·43	0·69	1·14	1·54	1·14	7·37
Leg 4	1·37	0·57	1·94	0·91	1·66	2·28	1·26	9·99
Pedipalp	0·46	0·57	1·31	0·86	1·14	....	1·03	5·37

The dorsal surface of the body is much darker than in the male, the saddle-shaped area on the scutum being dark-brown. The appendages and ventral surface of the body are coloured as in the male.

The chelicerae are smaller than those of the male and lack the large curved tooth on the posterior or ventral surface of the second segment.

The pedipalpi are smaller and less robust than those of the male. The large spine, which is present on the prolateral side of the trochanter in the male, is lacking in the female. The large curved spine in the distal half of the prolateral surface of the femur in the male is much smaller in the female and not so strongly curved.

Coxa I has three promarginal teeth, the middle tooth being large and the apical tooth small and bifid (fig. 295). Coxa II has a large triangular recumbent tooth, which projects forwards over the middle of the posterior margin of coxa I.

The genital operculum is much smaller than that of the male and measures 0·63 mm. long and 0·74 mm. wide. The lateral margins in the posterior two-thirds are coarsely tuberculate. Anteriorly the margin is smooth and rounded (fig. 296).

The legs resemble those of the male but the tarsal segmentation is 3, 9, 4, 4.

Localities: The holotype male was collected under fallen logs in *Notofagus* forest at Weldborough Pass, 25th August, 1953, and the allotype female was found in the neighbouring district of Gould's Country, Tasmania, 26th August, 1953.

Variations: In addition to the type specimens the collection contains one other female and three other males, all from the Weldborough Pass area. The males vary in body-length from 3·48-3·83 mm. and the females from 3·54-3·77 mm. All the males have four segments in tarsus I, but the number of segments in tarsus II varies from 9-11. The females have three segments in tarsus I, and 9-10 in tarsus II.

ACKNOWLEDGMENTS

This work was carried out under the auspices of the Trustees of the John Ralston Bequest and to them I am grateful for their interest and encouragement. For assistance in collecting harvestmen in many different parts of Tasmania I am indebted to the late Messrs. A. L. Meston and G. Craw. My thanks are also due to Dr. J. W. Evans, who conducted me on an excursion to the Ida Bay Caves, where the interesting opilionid, *Monoxyomma cavaticum* sp. n. was found. Further specimens of this harvestman have been collected for me by members of the Geology Department of the University. Finally, I wish to thank Messrs. C. Oke, D. E. Kurth and J. L. Hickman, all of whom have helped to build up the large collection of harvestmen examined during the course of this study.

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THE PRECAMBRIAN ROCKS OF TASMANIA

PART III, MERSEY-FORTH AREA

By

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(With 7 Text Figures, 3 Plates and 1 Map)

ABSTRACT

The area shows considerable relief and a complex land surface in which the following elements were recognised; a pre-Permian surface, a Tertiary surface of mature river erosion, a flat, post-Tertiary-basalt surface, a maturely dissected and a young plateau (Central Plateau). The area has been affected markedly by the Pleistocene glaciation which produced mammilated surfaces, U-shaped valleys, roches moutonnées, till and varves. The till in the Mersey and Forth Rivers has been cut into a well-developed set of river terraces which show a possible climatic control.

The rocks in the area consist chiefly of a thick sequence of regionally metamorphosed sediments of Precambrian age which have been subdivided into several groups and formations. They are overlain by thin basal Permian sediments which have been intruded by a Jurassic dolerite sill. Tertiary volcanism has been active with the accumulation of 400 feet of coarse pyroclastics and 400'+ of basalts.

The regional structure is shown to be similar to that in several places around the edge of the Precambrian "nucleus". A major syncline occurs in this area with a major anticline to the north, the folds trending at 280°. Two fault systems are present; high-angle reverse faults striking at 280° and transcurrent faults striking at 315°. Schistosity is well-developed parallel to the bedding of the Precambrian rocks which also show lineation trending at 280°.

INTRODUCTION

The area was mapped for the Hydro-Electric Commission from December, 1955, to early March, 1956. The base map was a two-inch to the mile, 50 feet contour interval map, supplied by the Department of Lands and Surveys. Typical rock specimens were collected and are housed in the Geology Department of the University of Tasmania; the numbers in this report are those in the Geology Department catalogue.

Location of the Area

The area is located near the headwaters of the Mersey and Forth Rivers, immediately east of the Cradle Mountain Reserve, and south of Lorinna, Liena and Mole Creek.

Acknowledgments

The author must acknowledge the considerable help given by Mr. J. Davies of the University of Tasmania and Mr. J. N. Jennings of the National University in Canberra in the interpretation of the physiographic history of the area. Mr. I. McDougall assisted in the field and carried out the mechanical analysis of the till. This report is published by courtesy of the Tasmanian Hydro-Electric Commission.

Previous Literature

There has been no previous work published on this area but literature relevant to the adjacent areas is available.

Ward (1909) included the rocks to the south in a general summary of the Precambrian rocks of Tasmania. Benson (1916) made some brief geological notes on the area around Cradle Mountain. Reid (1918) gave a general description of the Mount Pelion region and made some reference to the geology along the Forth River. Clemes (1924) described the glacial features of the Lake St. Clair district. Lewis included this area in his account of Pleistocene glaciation in an extended series of papers, particularly (1932) and (1944). David (1950) made a general reference to glaciation in this area. Elliston (1954) mapped to the north around Lorinna.

PHYSIOGRAPHY

The area is one of considerable relief being situated where the edge of the high Central Plateau has been dissected by the north-flowing Forth and Mersey Rivers. The land surface is complex, being controlled by a number of different erosive processes which have acted on different structures.

The following physiographic units have been recognised:—

(1) Pre-Permian surface.—A flat surface generally at about 2400 feet but dipping south, exposed in some places by the stripping off of the sediments.

(2) Pre-basalt (Magg's) surface.—An undulating surface of fluviatile erosion of early Tertiary age dominated here by a mature valley which was developed by modification of the pre-Permian surface.

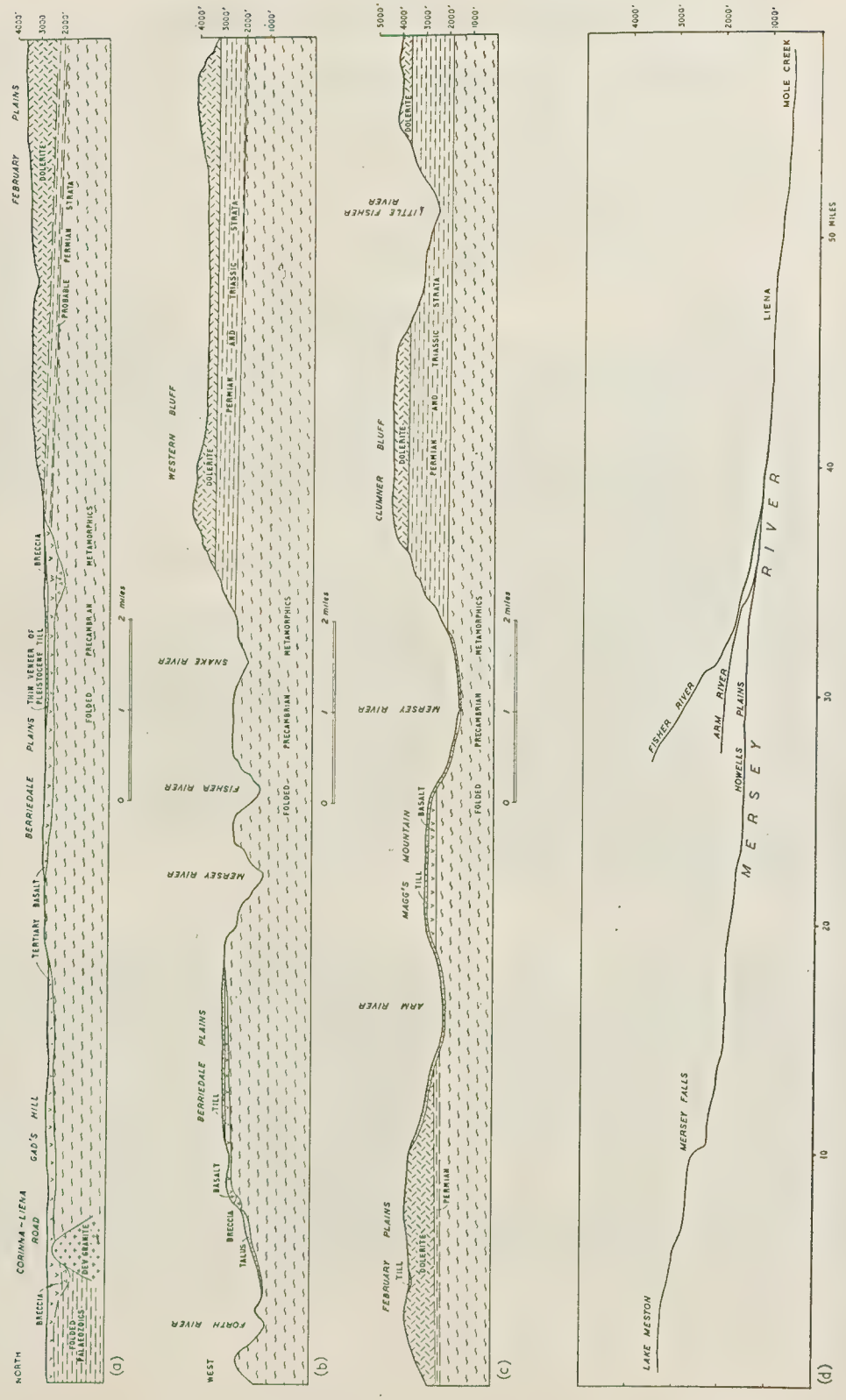


FIG. 1 (*a*, *b*, *c*).—Cross sections showing the physiography of the region and its relation to the geology.
FIG. 1*d*.—Longitudinal profile along the Mersey and its tributaries in its upper section. It has been glaciated for about the first 40 miles.

(3) Post Tertiary-basalt (Berriedale) surface.—A flat surface which is underlain by a variety of rocks and which descends from 3600 feet to 2350 feet in a northerly direction in 20 miles.

(4) Central Plateau.—A high (4000'+) extensive surface controlled by a great resistant dolerite sill. It is bounded on the north by the Western Tiers, a steep line of cliffs.

(5) Fold-mountain surface.—The strongly folded Palaeozoic rocks around Lorinna, Mt. Roland, Mole Creek, &c., show a strong W-N-W "grain" with ridges and cuestas.

(6) Karst surface.—An excellent, mature Karst landscape is developed in restricted areas near Mayberry which are underlain by Gordon Limestone.

The land surface owes its form to three processes:—

(*a*) Normal (river) erosion has been dominant with the production of the present valleys and the pre-basalt surface while the pre-Permian surface is probably a peneplain owing much to fluviatile action.

(*b*) Glaciation during the Pleistocene Epoch has greatly modified certain parts of the area, particularly the top of the Plateau and the river valleys.

(*c*) Pediment action has been dominant in the formation of the Tiers during scarp retreat.

Land Surfaces

1. *Pre-Permian Surface*

The surface upon which the Permian sediments were deposited has been exposed in some parts of the area lying between the Mersey and the Plateau near the Mersey-Arm junction. It has been dissected by the Fisher River and its tributaries. and remains as a flat top to a number of hills, e.g., Union Peak. It descends from 2450 feet to 2200 feet altitude in a distance of six miles from north to south, there being a component of dip of the Permian sediments in this direction. Ford (personal communication) reports that this surface changes in attitude and dips north-easterly just south of Western Bluff. This surface, which is underlain by folded Pre-cambrian and Lower Palaeozoic rocks, has had a profound effect, either directly or indirectly, on the development of all other surfaces in this area.

2. *Pre-basalt (Magg's) Surface*

This is defined as the land surface exposed immediately prior to the Tertiary volcanism. It has been buried by the basalt and its form was obtained by mapping the base of the basalt. The contour map, fig. 2, which shows the approximate configuration of this surface, was obtained by plotting the base of the basalt on a 200 foot contour interval map using the technique developed by Carey.

3. *Berriedale Surface*

This is a broad surface which has been dissected by the Mersey and Forth Rivers and remains as remnants, one of which is the flat-topped divide between the Mersey and Forth Rivers extending north of Mts. Pillinger and Oakleigh, through the February Plains, Magg's Mount, the Berriedale Plains and extending beyond Gad's Hill.

Magg's Mount is the flat-topped divide between the Mersey and Arm Rivers. The sides are steep and the top is generally at 2800 feet although there are undulations up to 2975 feet. It is underlain by a flat sheet of Tertiary basalt about 400 feet thick with a superficial layer of Pleistocene till, which may reach 100 feet in thickness.

The February Plains form the interfluve between the Forth and Arm Rivers north of the Mt. Oakleigh-Mt. Pillinger scarp. It reaches an altitude of about 3900 feet in the south but much of it lies at approximately 3600 feet altitude. It is 10 miles long and triangular in shape being six miles across in the southern end and two miles across in the north. It is underlain by a thick dolerite sill and thus is structurally akin to the Plateau but it is generally about 400 feet lower and is separated from it by the Mersey River.

The Berriedale Plains are the flat extension northwards of the February Plains and lie between the Mersey and Forth Rivers at an altitude of 2850 feet. The plains are about two miles wide from east to west and five miles long from north to south. They are underlain by Tertiary Basalt with a surface layer of Pleistocene till and are structurally similar in every way to Magg's Mount.

The Berriedale Plains descend gently to the north and after a slight depression become the Emu Plains then Gad's Hill. This has an altitude of about 2550 feet and is underlain by folded Precambrian and lower Palaeozoic sediments, Devonian granite and Tertiary Basalt.

Thus as the section fig. 1 (*a*) shows, there is a broad surface (here defined as the Berriedale surface) a residual of which forms the interfluve between the Mersey and Forth Rivers and which descends from south to north. It lies at 3600 feet at the February Plains, 2850 feet at the Berriedale Plains, 2550 feet at Gad's Hill and 2300 feet to the east of Lorinna. It averages about four miles wide and falls 1300 feet in its length of 20 miles. Another residual occurs on the west side of the Forth River where the surface descends to the north in exactly the same way.

This surface is independent of structure and rock type. It descends to the north even though the dolerite and pre-Permian surface descend to the south at the February Plains; and it cuts across folded Palaeozoic and Precambrian rocks and Tertiary basalt. It owes some of its flatness to the upper surfaces of the basalt flows which filled up irregularities in a previously undulating landscape and it has been partly smoothed by the Pleistocene glaciation.

4. *Central Plateau*

This is a major physiographic feature of Tasmania and extends over hundreds of square miles as a high level surface with a general altitude of 4000 feet. It rises to 4600 feet in some places and is bound in the north and east by the steep scarp of the Western Tiers. The western boundary of the Plateau is indefinite but has been regarded as approximating to the eastern side of the Cradle Mountain Reserve and the Mersey River; thus the

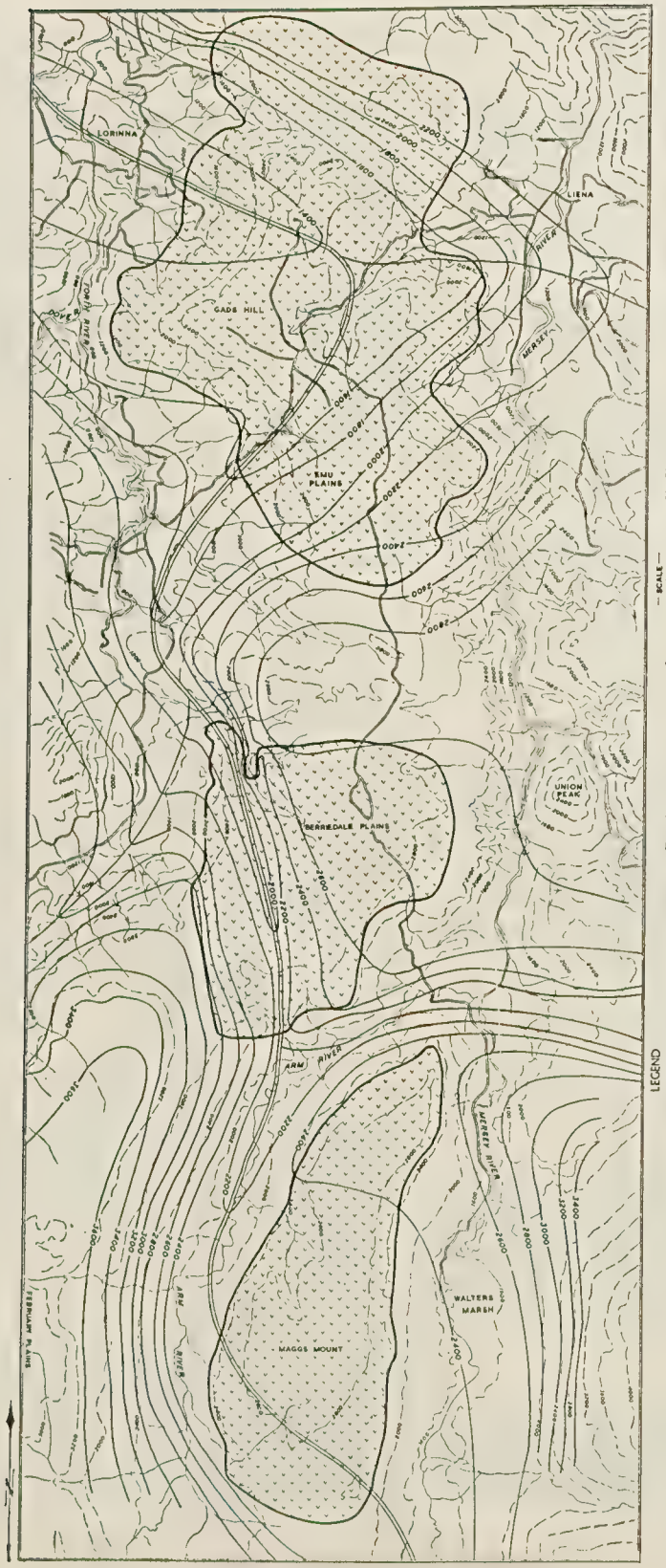


FIG. 2.—Contour map showing the distribution of Tertiary basalt and the relation between the pre-basalt topography (heavy contours) and the present surface (light contours).

rugged country in the Reserve with its peaks reaching over 5000 feet, although structurally cognate, may be regarded as a separate physiographic unit. The upper surface of the Plateau is comparatively flat, especially towards Great Lake but is cut by many 600 feet deep valleys in the vicinity of the Walls of Jerusalem, where it has been strongly glaciated. There is an irregular, raised rim which reaches an altitude of 4600 feet and this is a characteristic feature of the Tiers.

The Plateau owes its form to a resistant dolerite sill which is over 1000 feet in thickness and from which practically all the roof sediments have been stripped. In some places (Liaweenee, Wentworth Hills) there are small areas of Tertiary basalt resting on the upper surface.

The scarp of the Plateau constitutes the Western Tiers and is made up of an upper, dolerite cliff as much as 1000 feet high although generally not being more than 400 feet, and a lower, steep slope up to 2000 feet high underlain by subhorizontal Permian and Triassic sediments. Giant scree slopes of dolerite debris are a common feature.

The Plateau originally extended at least as far west as the Eldon Range and Mt. Dundas but the dolerite and the Permian and Triassic sediments have been removed, except for a few small outliers. The reason for the abrupt change from a youthful, undissected plateau in the east to a mature strongly broken plateau in the west is not known although some suggestions were made by Spry (1956).

The Western Tiers from Western Bluff to Table Mountain is practically unbreached for about 80 miles and the major drainage from the youthful Plateau is to the south-west except where locally controlled by Tertiary faulting. The present Central Plateau is a small remnant of the surface which must have extended over at least two-thirds of Tasmania during the late Mesozoic and it remains unbroken because of the lack of north flowing rivers.

River System

The two chief rivers are the Forth and the Mersey and these show quite straight courses for 20 miles in this area. Both rivers show a long and complex history of development extending back to the beginning of the Tertiary Period.

Mersey

The longitudinal profile of the Mersey (see fig. 1) shows many of the characters typical of glacial valleys.

The Mersey rises high on the Plateau at Lake Meston and runs south-west across morainal ridges and glacial steps before descending rapidly down the scarp in a series of waterfalls. In this section it descends 2000 feet in five miles in a U-shaped valley. Beyond the turn to the north at Cathedral Mountain, past Mt. Pillinger and Rugged Range to Howell's Plains it has a markedly different character. It meanders slightly across its broad, flat, till covered floor which is up to one mile wide, and it has a characteristic U-shaped section with walls nearly 2000 feet high. The valley takes two right-angled bends. It has cut chiefly through Permian sediments in this section and spurs are lacking.

Between Walter's Marsh and the Arm River junction, the valley is narrower, although the U-shape persists (fig. 3*c*, 3*d*). The river here cuts through steeply dipping Precambrian sediments which strike obliquely across its course. Steep cliffs, truncated spurs and smoothed quartzite faces occur. Low rock bars cross the river in several places. The river terraces which are strongly developed in this section are described in detail later and are shown in fig. 5.

North of the Arm junction (fig. 3) the river becomes narrower and has steep sides with a V-shaped section. The bottom is still rather flat in parts and some terraces are developed. While it is not obvious in the field, the contour maps show spurs which appear to be truncated but interlocking spurs occur just north of the Fisher-Mersey junction. Quartzite scree slopes are prominent in this section.

The valley becomes broader and flatter bottomed at Liena (fig. 3) where the river has cut through Gordon Limestone. There is a gorge through the anticlinal ridge of Ordovician quartzite and then the river turns east where it occupies a broad flat-bottomed limestone valley west of Mole Creek (fig. 3).

Forth River

Although not studied in detail, the Forth River shows features in common with the Mersey. It rises in the area around Mts. Achilles, Ossa and Pelion East and has a steep gradient west of Mt. Oakleigh. From here north to Gisbourne's Hut it occupies a broad, straight, deep, U-shaped, glaciated valley. North of Gisbourne's Hut the valley narrows and becomes V-shaped (although interlocking spurs are lacking) until north of the Dove junction where it passes out of the Precambrian into Ordovician quartzite and limestone. In the vicinity of Lorinna it occupies a moderately broad valley which is underlain by limestone (fig. 3).

Arm River

The Arm River is a tributary of the Mersey and is only about 14 miles in length. For the greater part it occupies a very broad valley (fig. 1*c*) between the high February Plains and Magg's Mount. Spurs are truncated although two low rock bars cross the river. There is an abrupt change of character in the last 2½ miles before it joins the Mersey and here it descends rapidly with rapids and small waterfalls through a small gorge cut in the floor of the valley.

Erosive Processes

The most important agents responsible for the development of the present physiography were the Mersey and Forth Rivers, aided by the Arm, Fisher and Little Fisher Rivers. The area is youthful, being a complex plateau slightly dissected by young river valleys.

The effect of ice action during the Pleistocene glaciation although quite extensive is quantitatively less important than river action. The glacial physiography will however be discussed in detail because its effects are for the most part much more important than has been recognized in the past.

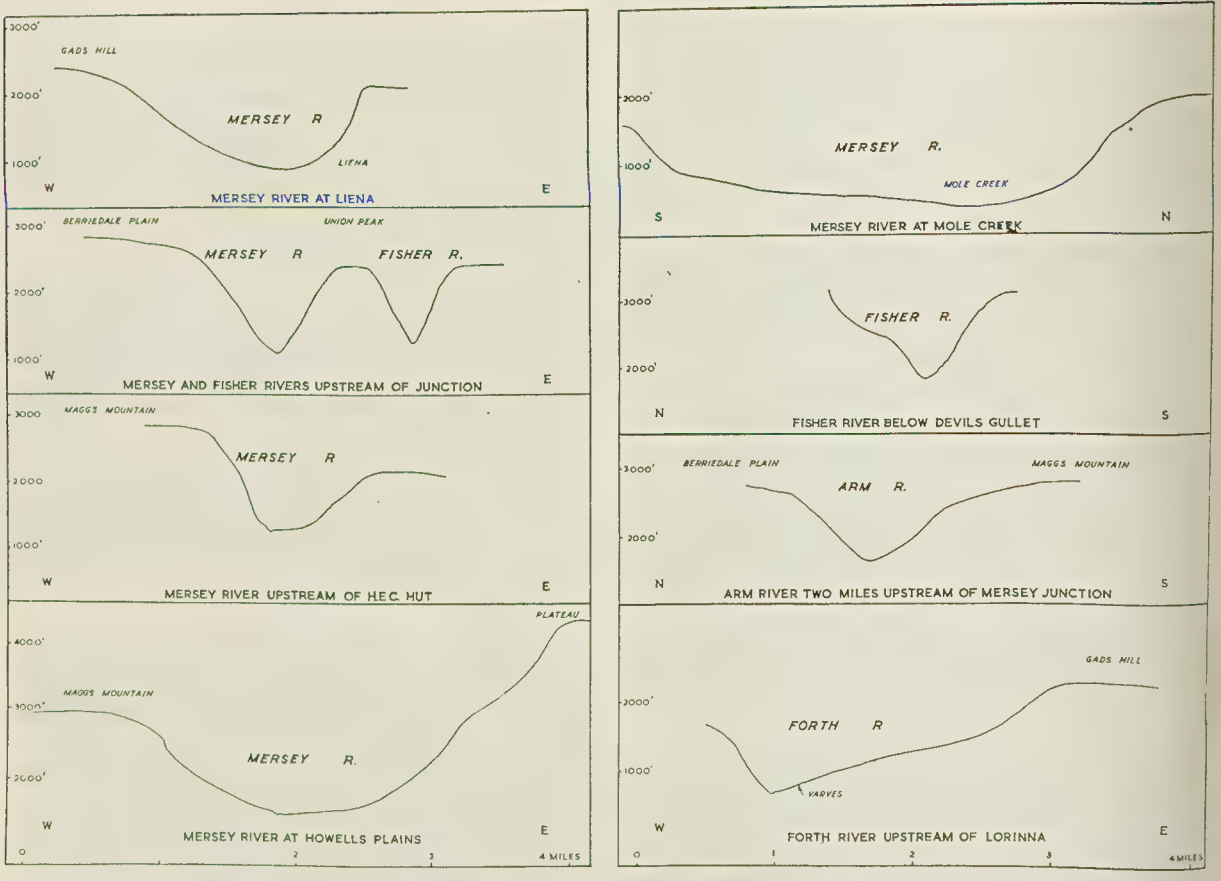


FIG. 3.—Transverse sections across the valleys of the Mersey, Forth, Arm and Fisher in various places.

The Plateau shows abundant evidence that it was covered by an ice cap of considerable magnitude and the complex effects are at present being studied in detail by J. N. Jennings of the National University, Canberra. At present it can be said that one centre of the cap was in the vicinity of the Walls of Jerusalem and that the extensive area of large and small lakes represent the eroded zone with areas of deposition to the east and south. The ice spilled over the edge of the Plateau in many places, filled the previously existing Forth, Mersey and Little Fisher Rivers and covered the interfluves. All these rivers (together with the Arm) show clear evidence of glacial action. They possess U-shaped valleys with truncated spurs, hanging valleys, smoothed quartzite outcrops, and roches mountonnées on their floors. There are end moraines in the Little Fisher Valley and varved shales in the northern part of the Arm, Fish and Forth Rivers (south of Lorinna). In the Arm River, the main body of varve laps against moraine material but the characteristic form of end moraines is not very clear. Some varved shale lying between till indicates slight recession and re-advance of the glacier (plate No. 2).

There are several more points of considerable importance which indicate that the ice in the Forth-Arm-Mersey area must have been nearly 2000 feet thick. In addition to the clearly demonstrated glaciation of the river valleys, the flat-topped interfluves (i.e., Magg's Mount and February and Berriedale Plains) and the high steep sides of the valleys are covered with many feet of till. The nature of this material is described in detail later but briefly it consists of a mixture of round dolerite boulders in a fine matrix. This material rests on Tertiary basalt at Berriedale Plains and Magg's Mount and in the latter case there is no way that such large (up to 6 feet) boulders of dolerite could be transported for 10 miles across a flat plain except by glacial action.

It would then appear that the ice flowed off the Plateau along the Forth River but *across* the Mersey River, possibly covered Mt. Pillinger and Mt. Oakleigh and passed across Magg's Mount and the February and Berriedale Plains to the Forth River. It is possible that the upper parts moved in this direction while the movements at the base of the sheet were controlled by the underlying physiography and the ice there flowed north-

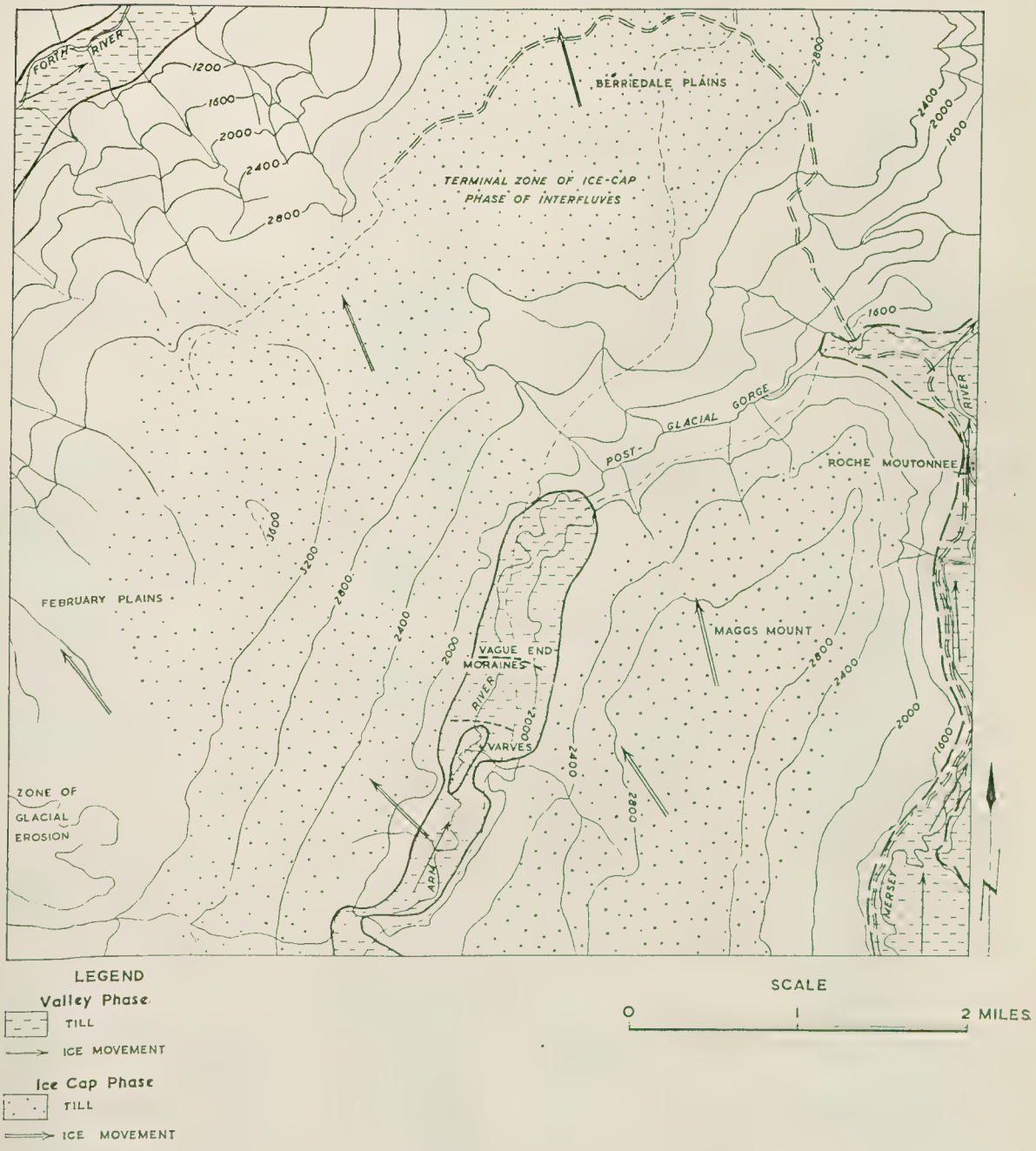


FIG. 4.—The approximate distribution of Pleistocene glacials and the probable directions of ice movement during the two phases of the glaciation.

wards along the Forth, Arm, Little Fisher and Mersey Valleys. The ice would then be at least 1600 feet thick and probably not less than 1800 feet in the Arm-Mersey-Forth area.

Many of the highest peaks in the Cradle Mountain Reserve show glacially smoothed sides and a sharp top with abundant evidence of frost action. This sharp difference suggests that the peaks might have projected through the upper surface of the ice cap as nunataks and that the altitude of the cap reached approximately 5000 feet in its thickest parts where it had a maximum thickness of 3000 feet. There is no doubt that frost attack is proceeding at present and that there has been sufficient time since the glaciation for the high dolerite peaks to have become jagged, but some parts of the Mersey valley, e.g. Rugged Range, show sharp, rough outcrops immediately next to smoothed, glaciated areas and it is clear both on the air-photos and in the field that some places within the glaciated areas have not been affected by glacial action. The altitude of the upper surface appears to have been about 4000 feet at Mts. Oakleigh and Pillinger and 3000 feet at the Berriedale Plain.

It is difficult to estimate the extent of the valley glaciation although the ice undoubtedly flowed north along the valleys beyond the edge of the thick ice cap. The rivers are clearly glaciated as far north as a line (Gisbourne's Line) joining Gisbourne's Hut, the Arm-Mersey junction and just south of the Devil's Gullet, but there is some evidence that the valleys may be poorly glaciated for at least three miles north of this line which marks the moraines on the Little Fisher and the varves and moraine of the Arm. The varves in the Forth River are eight miles north of this line and 150 feet above river level and probably filled a lake dammed behind a 400 feet high terminal moraine at Lorinna, the remnants of which are vaguely recognisable on the sides of the valley. North of the line, the Forth, Mersey and Fisher (particularly in the Devil's Gullet) show V-shaped valleys lacking the typical glacial form, but as there is no evidence of extensive post-glacial river erosion, it seems that all these valleys must be feebly glaciated. There oppear to be truncated spurs in the Mersey for nearly 10 miles north of this line but as the valley shows no abrupt changes in character in this section it is not possible at present to recognize the limit of the glaciation. Cross sections across the Mersey valley at several points and also the Arm and Fisher valleys are shown in figs. 1, 3 and 4.

It is difficult to divide the glacial epoch into distinct stages but it is clear that apart from remnants of an early cirque-forming phase, there was a major ice cap and a later valley phase. It is considered that these are phases of one major glaciation.

The old cirques which have been almost destroyed by ice moving *across* them during the ice cap phase occur further south on the Plateau and were not studied, and for this reason are not discussed here.

During the ice cap phase, the ice moved to the north-west across the interfluves approximately as far north as the Gisbourne line and extended further northwards along the valleys as tongues. It is difficult to recognize the terminal moraines of the ice cap although the ground moraine covers the landscape. There is a vague moraine at Lorinna but it seems possible that the terminal moraines may have been removed by melt waters during the retreat of the ice cap.

The second phase was less severe and the glaciers were restricted to the valleys. Well developed glacial valleys were produced and striae and roches mountonnées show the ice to have moved northwards along the valleys. The Gisbourne Line marks the northern-most limit of the distinct U-shaped sections of the Mersey and Forth Valleys, the till on the floor of the Mersey, the end moraines of the Arm and Little Fisher and the varves of the Arm.

At present it is not possible to decide whether the first and second phases were separated by an interglacial period or whether the ice cap merely shrank leaving valley glaciers which were active for a considerable period with minor advances and recessions.

River Terraces

There is an extensive development of river terraces on the floors of the Forth and Mersey Rivers. The Mersey terraces are best shown in the two mile long section between the Mersey-Arm junction and Howell's Plains and these have been mapped in some detail as shown in fig. 5. Mapping was carried out using the pace and compass method for the base map and establishing heights by clinometer. The heights shown on the map are those above the river level at the nearest point. The terraces are generally well preserved and undissected with continuous, clear-cut flat surfaces. They are composed of a uniform, unsorted boulder-rich material and evidence produced later indicates that this is Pleistocene till. The terraces range in height from 3 feet to 400 feet above river level, the lower, more perfect ones being cut in till and the higher, fragmentary ones being cut in the solid rock of the spurs. There is no doubt that the terraces have been *cut* and not *deposited* by the river.

The Mersey Valley was occupied by a glacier during the last stage of the glaciation and was joined by a tributary glacier down the Arm. Removal of the ice left the floor of the Mersey Valley covered with at least 160 feet of till which definitely extended as far north as the Mersey-Arm junction and probably as far as the Mersey-Fisher junction. Further north at Liena the river terraces are composed of better sorted and rounded material which is probably fluvioglacial. The Arm contained 120 feet of till near its junction with the Mersey but this thinned rapidly upstream. It is difficult to estimate the actual thickness of till as the sides of the valleys and the interfluves are also covered. The terraces have been carved both in the valley walls and the till as the river cut down in post-glacial times.

The terraces do not show any marked differences in the type of material or soil development but may be divided into four groups depending on their heights above river level. There are small, flat-topped, rock-cut terraces at quite high levels on the side of the Mersey Valley. North-west of the Arm-

Mersey junction there are flats covered with water-worn quartzite and dolerite pebbles at 1800 feet, i.e., 400 feet above river level. There is a terrace at 1880 feet south-west of the junction above the Arm Bridge. There are similar vague flats on the west side of the Mersey opposite the Fisher River at 140* feet, 150* feet, 310* feet, 330* feet, 350* feet and 370* feet above river level. On fig. 5 are shown terraces at 160* feet, 150* feet, 145* feet and 130* feet, 120* feet and 95* feet.

The next group occurs at 75 feet, 65 feet, 65* feet 60 feet and 55* feet above river level and although fragmentary, they are better preserved and more extensive than the previous group. The 75 foot level is the highest cut in till and the 55 foot is the lowest rock-cut terrace. The next group occurs at 45 feet, 40 feet and 35 feet and these are very extensive, well preserved surfaces. All th previously mentioned terraces are too fragmentary to say whether they are matched or unmatched across the river, but although the 45 feet, 40 feet and 30 feet are well developed, once again this point is not clear. In some places the 45 feet and 35 feet are clearly matched across the present river but it is likely that the 45 feet on the west bank slopes down to 40 feet on the east bank and back to 30 feet on the west. Since the 65 feet level the river has progressively occupied less and less of the valley floor, and between the 40 feet and 30 feet level there was a distinct straightening of the river leaving truncated meanders and other parts of the course perched on the terraces. The river meandered around several low rocky hills on the 45 feet and 40 feet levels but these also were left stranded as the river straightened and cut downwards.

The group 30 feet, 26 feet, 20 feet, 16 feet, 10 feet and 3 feet are narrow and follow the present river course very closely. At the points marked T.B.L. there are marked constrictions of the course by islands and although there is continuity of surface of the terrace there is rapid decrease in height of 45 feet to 30 feet and lower from 40 feet to 30 feet. Above the constriction the surfaces of the terraces have a gentle slope indicating a flat grade with rapids across the temporary base level where the course narrowed and was held up by the hard quartzite bed rock.

There are two nodes showing restriction in the course of the river since the 45 feet and 30 feet levels.

The constant height of the upper surfaces of the terraces above the present river level indicates that the Mersey has not appreciably changed its grade since the 45 feet level and probably the 65 feet also. The Arm terraces however are more complex and show that the grade was much flatter at the 120 feet and 20 feet to 30 feet levels than at present; this is clearly shown by the terrace which is 30 feet above river level at the junction with the Mersey, but only 19 feet above at a point half a mile upstream. By contrast the 40 feet terrace of the Mersey is constant for half a mile and the 33 feet to 35 feet terrace rises only about two feet in almost one mile.

* Denotes rock-cut terraces.

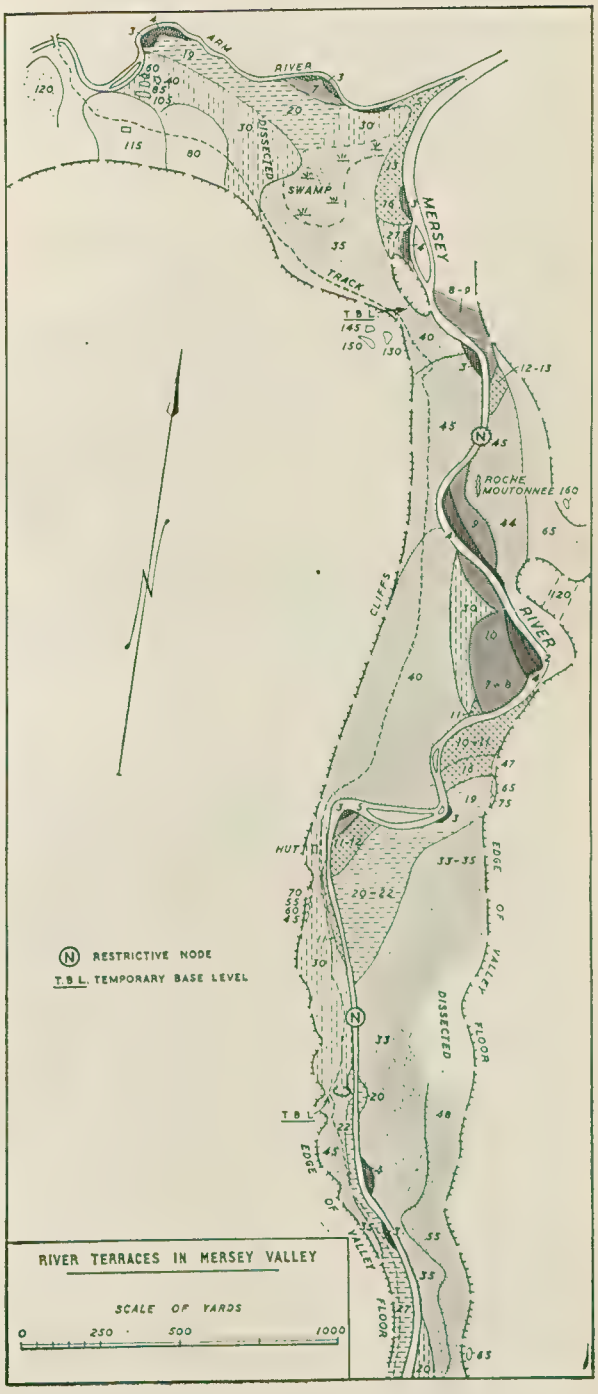


FIG. 5.—Sketch of the river terraces in the Mersey between its junction with the Arm and Walters Marsh.

At the close of the glaciation the Arm was left as a hanging valley perhaps 60 feet above the Mersey and the 120 feet and 110 feet terraces show it to have had a shallow gradient near the junction. However, as the Mersey cut quickly down through the till the Arm had to erode its quartzite floor and has produced a 60 foot gorge with waterfalls and rapids just above the Arm Bridge. In the zone at the Mersey-Arm junction there is a complex set of terraces shown in fig. 5 but no attempt has been made to interpret these.

A study of the river terraces reveals something of the history of the area since the Pleistocene and although the picture is by no means clear, the following interpretation seems likely.

The high level rock-cut terraces are possibly post-glacial as they occur in unprotected positions in areas which were clearly covered by ice and yet retains a cover of water-worn pebbles. It is possible that the valley contained till up to the 400 feet level and that the river meandered across this as it cut down in post-glacial times. Under these circumstances the meanders might cut nicks in the side of the valley wall in various places. This explanation requires a long period of active meandering and down-cutting and a great thickness of till in the valley.

It seems more likely that the flats were cut by meltwater streams flowing along depressions at the contacts of the glacier with the valley walls. These proglacial streams would be quite active. The varves in the Fish River were probably deposited in a lake dammed by the Mersey glacier at this time.

After the disappearance of the ice from this stretch of the river the Mersey proceeded to cut steadily down through at least 75 feet of till. This indicates a gradual alleviation of the climate and as the river showed no tendency to cut a gorge through the soft till it seems that there was neither a sudden release of meltwater nor a period of excessive rainfall.

The river has since cut a series of meander terraces as it swung from side to side, occupying progressively less and less of the valley floor. There was a slight change at the 55 feet level but the only distinct break in the river's history was at the 30 feet to 40 feet level. The river had been held up by two local base levels (shown in fig. 5) and had meandered behind them, but rejuvenation led to a straightening of the course and a rapid down-cutting. The series of terraces in 5 feet steps from 0 to 30 feet is probably related to the removal of local base levels further downstream.

It is unlikely that change in sea level either during or after glaciation would affect the river near its headwaters at a distance of 40 miles from the sea and 1600 feet altitude, and it seems that any rejuvenation must be related to increased rainfall as there is no possibility of any major river capture further upstream.

Gill (1954) has summarized evidence for climatic changes in Victoria during recent times. Although there is not necessarily any close relation between the climates of Victoria and Tasmania during this time, the Mersey terraces may be placed in their approximate time positions. If the correlation is

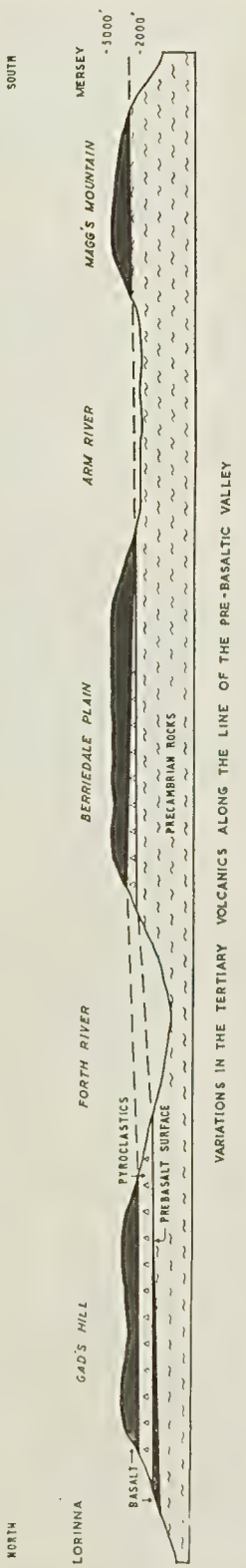


FIG. 6.—Sketch along the centre line of the pre-basaltic valley shown in fig. 2 indicating the relative distribution of lavas and pyroclastics.

correct, the period from the 75 feet to the 55 feet terrace would correspond to the gradually warming up from glaciation to the Post-glacial Thermal Maximum and this seems a reasonable fit. The rejuvenation at 30 feet would be associated with increased rainfall after the dry Thermal Maximum leading up to the Little Ice Age. The reconstruction here will not be clear until the history of the lower part of the river and the sequence of eustatic changes of the coastline are determined. One should not overlook the possibility of rejuvenation of the rivers due to isostatic recoil of the area following the removal of a large ice cap, although this ice cap was much smaller than known caps whose melting was followed by recoil.

Geomorphic Evolution

By the end of the Mesozoic Era, following intrusion of dolerite during the Jurassic Period and denudation during the Cretaceous Period it seems likely that the west-north-west trending Tiers were breached in this area by the north-flowing Mersey River. By both fluviatile action and pediment erosion, the Tiers retreated towards the west and east leaving an embayment. The softer Permian sediments were stripped off easily where not protected by dolerite and the rivers eroded this material until the underlying harder Precambrian sediments were reached. Thus by the early Tertiary (?) (perhaps Oligocene) a mature river system had been developed within this Mersey-Forth embayment. The land surface owed its form partly to the stripped pre-Permian surface. The dolerite of the February Plains stood above this level to the west and that of the Plateau to the east. The ancient Mersey occupied a channel cut through this surface. The channel is not recognizable at Howell's Plains, but where it is exposed in the Arm, it is 400 feet deep and at Gad's Hill possibly 600-800 feet. The Forth was quite probably a tributary which joined the Mersey near Gisbourne's Hut.

In the Tertiary the basalts were poured out along the valley line, filling the valley and then covering the adjacent flatter landscape. The occurrence of a 400 feet layer of coarse breccia and tuff on the floor of the buried valley suggests that the centre of volcanism may have been located somewhere between Gisbourne's Hut and Liena and that the lava flowed *upstream* towards Howell's Plains as well as downstream. This is supported by the fact that no source was found in the Howell's Plains area. Figure 6 shows the probable variation within the volcanics along the old Mersey Valley.

The Mersey became displaced by the basalt and cut a channel along its eastern margin thus taking up its present position and the Forth became a large river along the western boundary of the basalt. The Tiers of Western Bluff at this time would have been immediately east of the Mersey. Since the extrusion of the basalt, the following events have occurred:—

(*a*) The Forth has cut a valley 2000 feet deeper;
(*b*) The Mersey has cut a valley 1600 feet deeper;
(*c*) The Arm has appeared;
(*d*) The Tiers south of Western Bluff have retreated at least two miles, exposing a pre-Permian surface which is not covered by basalt;
(*e*) During the Pleistocene the valleys were smoothed and deepened possibly as much as 100 feet. The interfluves were possibly a little eroded but were more likely positions of deposition and possibly 100 feet of till was deposited on Magg's Mount.

STRATIGRAPHY

Beneath a widespread blanket of Pleistocene till the area is underlain by a thick sequence of metamorphosed sediments of Precambrian age. These are overlain unconformably by sub-horizontal Permian sediments which have been intruded by a sill of Jurassic dolerite. Tertiary volcanics occur above these rocks in a discontinuous meridional strip running through the centre of the area.

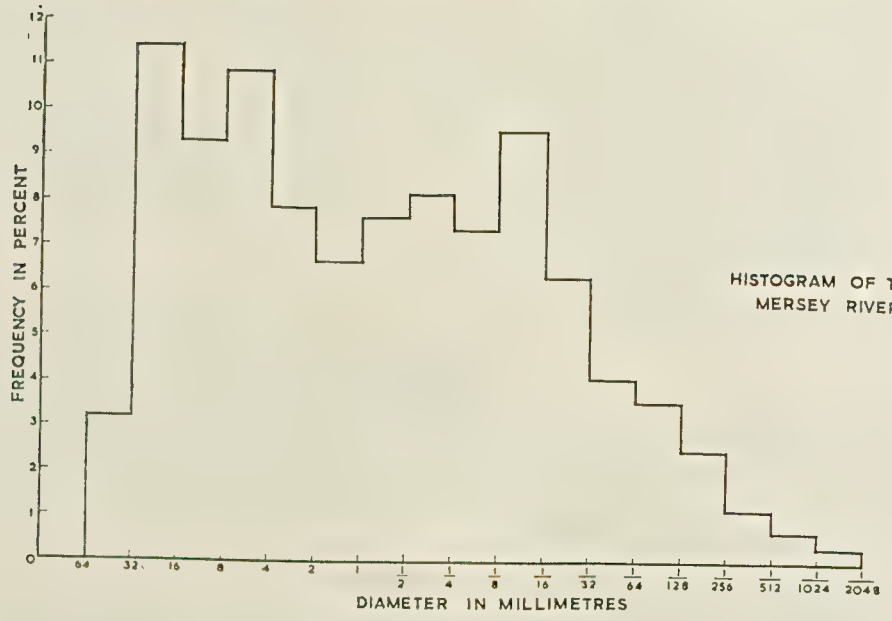
Precambrian Rocks

Within the restricted area there are approximately 14,000 feet of quartzites, mica schists (some with garnet or albite) phyllites and slates. The structural thicknesses as measured at the present time may be many times greater than the stratigraphic thickness due to pronounced thickening during folding. Exposures are poor so that the detailed structure cannot be determined and as the stratigraphy must follow the structure (not *vice versa* as in most structurally simpler rocks), it is not possible to unequivocably find the stratigraphic sequences. One structural peculiarity which causes considerable difficulty, is the lack of repetition of beds on the opposite limbs of major folds. As the sequences on the northern and southern limbs of the Mersey Syncline are quite different one must presume that there has been strike-faulting; there is no way of knowing whether either of the sequences is complete.

The best that can be done at present is to recognize the existence of separate groups possessing characteristic lithologies and to attempt to put these in their correct order. It must be emphasised that differences in the apparent degree of metamorphism of two rock-types (e.g., garnet-schist and slate) does not necessarily mean that the more altered one is older and separated from the less altered by an unconformity.

Howell Group

This group is probably the oldest in the area although the stratigraphic position is rendered obscure by faulting. It exceeds 5000 feet in thickness and consists of mica schists, garnet-mica schists, albite-mica schists, mica-quartzites and pure quartzites. These all show pronounced evidence of regional metamorphism. The type locality for the group is along the western wall of the Mersey Valley at Webster's Marsh. It also occurs along the southern end of the track to the Pelion Wolfram Mine on the Forth River.



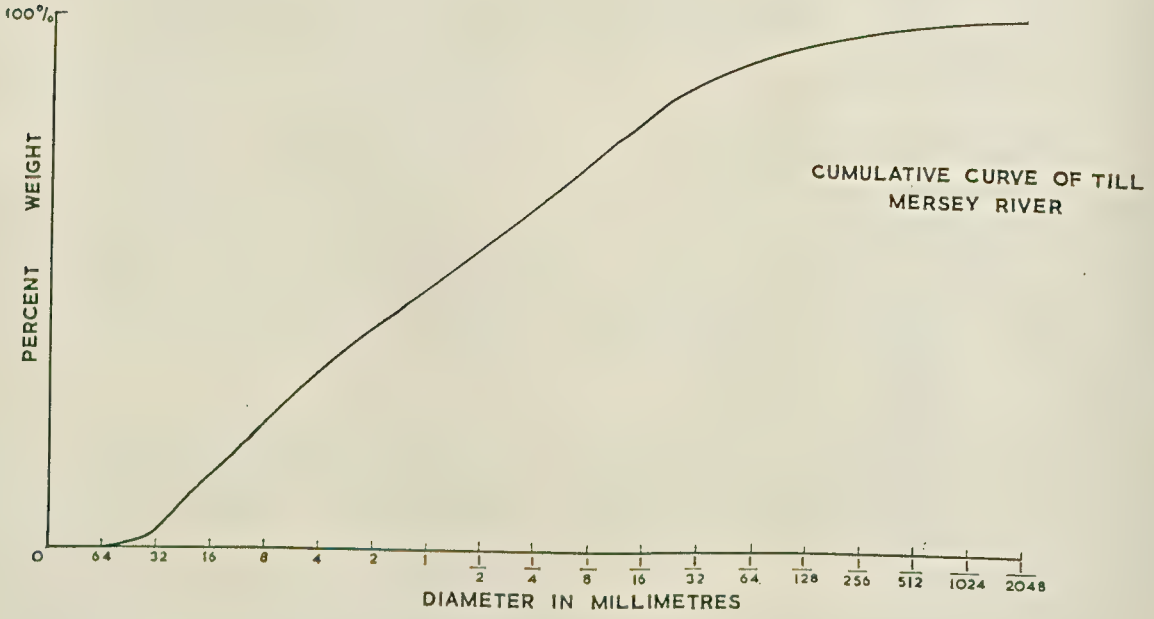


FIG. 7.—Histogram and cumulative curve of Pleistocene till from the Mersey Valley. Analyst: I. McDougall.

Fisher Group

This group probably lies above the Howell Group and below the Arm Schist. It exceeds 5000 feet in thickness and consists of interbedded formations of slate and quartzite with the latter dominant. The type locality is the western side of the Mersey River between the Fisher River and a point half a mile north of the Arm River. The group is well exposed on the Forth River for several miles south of Gisbourne's Hut.

The slates have a very characteristic appearance, being black with thin ($\frac{1}{4}$") bands of light quartzite showing contortion and possessing a moderately well-developed cleavage oblique to the bedding.

The major quartzites are massive and pure, and show well-preserved ripple marks and even cross-bedding.

Arm Schist

There is about 2000 feet of muscovite, garnet and albite schist with minor quartzites occurring at the Mersey-Arm junction and probably lying above the Fisher Group and below the Magg's Quartzite. This formation is probably represented on the other side of the Mersey Syncline by the garnet and albite schists occurring along the western side of the motor track half to one mile south of the Hydrographic Hut on the Mersey River.

Magg's Quartzite

Massive to well-bedded quartzites occur in the centre of the Mersey Syncline and are exposed along the Mersey River motor track for one mile north of the Hydrographic Hut. The formation overlies the Arm Schist and thus is the youngest found in this area. Folding in the axial zone of the Syncline makes the measurement of the thickness of the quartzite quite impossible but there is probably in the order of 2000 feet exposed.

The quartzite is generally massive and thickly bedded but some specimens are vitreous saccharoidal, ripple-marked, laminated, schistose or lineated. Tourmaline needles along the bedding-schistosity of one specimen give an appearance similar to that of the Raglan Quartzite (Spry, 1957).

Dove Schist

There are dull-green mica schists on the Forth River just south of the Dove-Forth intersection and these are correlated with about 5000 feet of garnet and mica schist exposed along the Mersey Forestry Road extending north of a point about half a mile north of the Mersey-Fisher junction. From its structural position on the flank of the Fisher Anticline, lying below the lower Palaeozoic strata, this could be the youngest formation in the area.

The following section is tentatively advanced.

Dove Schist	5000'?
Magg's Quartzite	2000'?
Arm Schist	2000'?
Fisher Group	5000'+
Howell Group	5000'+

The lithological similarities of the Arm Schist, Howell Group and Dove Schist suggest that these might be equivalent but the Arm Schist is much thinner than the Howell and Dove, and the Howell contains much quartzite whereas the Dove contains practically none.

Permian System

1. *Forth Section*

A total of 250 feet only of Permian rocks overlie the Precambrian unconformably along the upper slopes of the Forth River, west of the February Plains. The Permian is poorly exposed but sections are visible in some of the steep creeks which flow down from the February Plains into the Forth. The lithology of the basal Permian is quite unusual when compared with exposures elsewhere in Tasmania, although it is typical of the area between Western Bluff and Cradle Mountain. Apart from a general induration due to the Jurassic dolerite which has intruded just above these rocks, they are characterised by their white colour, well rounded pebbles and lack of fossils.

The basal conglomerate is 50 feet thick and contains well-rounded quartzite and schist pebbles up to three inches across in a white sand-silt matrix. Towards the base there are beds of sandstone one foot thick but at the top the proportion of matrix decreases and the rock is a typical quartz conglomerate.

The conglomerate passes upwards into a light-grey micaceous sandstone 120 feet thick which weathers to a red colour.

This passes upwards into a light-grey, shaley, micaceous siltstone 40 feet thick which becomes sandy and pebbly and passes into a buff pebbly sandstone. The last formation is only visible for a few feet as Jurassic dolerite has intruded at this level.

2. *February Creek*

There are Permian rocks exposed in the bed of the February Creek which is the southernmost tributary of the Arm from the west. It is very probable that Permian sediments occur along the western side of the Arm Valley where it shows a series of distinct benches but the whole is covered with a persistent layer of Pleistocene till. The following beds probably lie almost immediately above the sequence given above for the Forth River.

The lowest bed appears at an altitude of 2320 feet and is a buff coloured sandstone, with streaky irregular bedding and abundant rounded pebbles, usually one inch across. It is massive to flaggy in outcrop. After 10 feet of this the rock becomes less pebbly for 10 feet then the next 10 feet is much more pebbly and fossiliferous. There are pectens (up to three inches across), spirifers and martiniopsids.

The next bed is 30 feet thick and is tillite with abundant boulders in a sandy matrix.

This is followed by 10 feet of "Fontainbleu" sandstone with scattered pebbles. It is a medium-grey greywacke sandstone with large glittering plates of calcite and is described in detail later.

The last bed begins at 2390 feet but outcrops cease after a few feet until dolerite appears at 2600 feet. It is a tillitic greywacke which is dark-grey and very massive with abundant large boulders up to four feet across.

Jurassic System

The Jurassic Period was one of intrusion, and the thick dolerite sill of the February Plains intrudes the Permian strata only about 250 feet above the base. The dolerite has been eroded towards the north, but at Mt. Oakleigh is about 1000 feet thick.

Tertiary System

The rocks formed during this period are almost entirely volcanic in origin, the only exception being a small patch of fluviatile breccia on the northern end of Magg's Mount at 2415 feet altitude.

There is about 10 feet of this breccia visible but it may extend for 50 feet to 100 feet up the hill. It is horizontal and rests with marked unconformity on the eroded surface of the steeply dipping Precambrian quartzites. The lowest two feet is sandy and well cemented with abundant angular boulders up to three inches across. The rock is poorly sorted. This grades upwards into a bed with abundant rounded and angular boulders in a sandy matrix. Many of the boulders stand on their ends.

The volcanic rocks may be divided into two main parts. The lowest portion which is exposed only in the bottom of the buried valley between the Arm and Forth Rivers consists of coarse volcanic breccia with vitric tuffs and some white clays. This reaches 400 to 440 feet in thickness in the Forth Valley.

Overlying this is between 400 and 440 feet of basalt being composed of at least 10 flows.

The section in the Arm Valley contains more basalt (600 feet?) and the pyroclasts consist only of tuff probably about 100 feet or so in thickness, with some white clays.

Pleistocene Epoch

The rocks formed at this time were all glacial. Much of the landscape is covered by a layer of till which is probably normally not more than 20 feet thick but reaches 50 feet in places and would certainly be 120 feet in parts of the Arm, Fish and Mersey Valleys.

There is at least 10 feet of varved clay in the Arm Valley and probably more in the Forth Valley. At the bridge near the Dove Mill, on the Forth River, varves 20 feet thick cover the Precambrian rocks, and further downstream, about three miles south of Lorinna, the varves occur in a road cutting about 150 feet above the present river.

In the Arm River there is about three feet of varve forming a layer within a thick till which is overlain upstream by the main thickness of varves.

PETROLOGY

The chief petrographic characteristics of the rocks met in this area are summarized and criteria given for recognizing various types. Extensive petrological investigation of the genesis of these rocks is not given here and will be presented elsewhere.

Precambrian Rocks

These are regionally metamorphosed sediments, originally chiefly arenites and pelites, which have suffered considerable deformation. The members of the Howell Group, Dove Schist, Arm Schist and Magg's Quartzite belong to the garnet zone but the slates of the Fisher belong to the chlorite zone.

Howell Group

This is a sequence of schists and quartzites. The schists are generally coarse and glossy, and rich in muscovite with knots of garnet and albite. There is a good bedding-plane-schistosity with an irregularly developed fracture cleavage at about 30°. Lineation is well shown in some specimens.

Specimen 7408 is a glossy, contorted schist with a lineation rather than a schistosity. In thin section it is coarse-grained and consists of quartz and muscovite with about 10 per cent of albite and a little biotite and accessory zircon and tourmaline. No. 7387 is coarse and platy with some knots but no lineation. It differs from the previous specimen in containing more albite (large poikiloblastic porphyroblasts with single albite twinning), some chlorite and accessory rutile, apatite and zircon.

Specimen 7388 is an excellent example of these schists. It is an albite-rich, quartz, garnet, muscovite schist with much chlorite which has replaced garnet and possibly biotite. This shows slip planes at an angle to the major schistosity with quartz and chlorite growing along them.

The quartzites are rather fine-grained rocks forming beds a hundred or so feet thick. They tend to platy with thin bands of muscovite and are characterized by a strongly developed lineation.

Fisher Group

This group consists of alternations of quartzite and slate in beds about a thousand feet thick.

The quartzites are white, massive and thickly bedded with well developed ripple marks and cross-bedding in some specimens. Despite the preservation of these sedimentary structures the rocks show evidence of complete internal reconstitution and deformation. The original coarse clastic quartz grains have been broken down in size giving the typical "mortar" texture of cataclasites, i.e., large, xenoblastic or lenticular quartz grains showing undulose extinction and "Boehme" lamellae, set in a fine-grained matrix of recrystallized quartz with a strong preferred orientation.

Numbers 7394 and 7405, from the western bank of the Mersey River, about one mile south of its junction with the Fisher are characteristic examples. They are massive in the hand specimen with tiny white spots which are seen to be feldspar by examination under the microscope. The rocks are fine-grained with a strongly crushed texture in which the quartz shows sutured margins. Most notable is the presence of about 20 per cent of feldspar, microcline and albite (this is the first record of microcline in Precambrian rocks in Tasmania). The feldspars are quite rounded and show undulose extinction, bent twin planes, are clouded with inclusions and have a thin peripheral layer of muscovite flakes. These feldspars are so different

from the metamorphic feldspar in the adjacent schists that it is not unlikely that it is original clastic feldspar. The preservation of such relics in a rock which contains recrystallized quartz has been recognised elsewhere many times. This fact is important because it means that the original sandstones were at least feldspathic and in some examples, arkosic.

The slates of the Fisher Group are lithologically distinctive and are the distinguishing feature of this group. The name "slate" is used to separate the rocks from the schists and phyllites of the area even though the term might not strictly be correct. The rocks are dark-grey and fine-grained with alternating pelitic and arenaceous layers averaging about one-eighth inch thick. The thin layers are puckered into tiny crenulations and there is a distinct cleavage, oblique to the bedding, visible in the hand specimen. Most examples are glossy and coarser than the average slate and might be better termed phyllites.

In thin section, e.g., numbers 7406 and 7390, they are seen to be very fine-grained rocks consisting chiefly of quartz and sericite with accessory zircon and iron ore. The cleavage is due to the presence of parallel mica laths and elongated quartz crystals and clearly transgress the alternating mica and quartz-rich layers which are the bedding.

Arm Schist

The garnet, mica and albite bearing schists of this group together with their schistose quartzites are sufficiently similar to those of the Howell Group as to warrant no further detailed description.

Magg's Quartzite

This quartzite is generally thickly bedded but there are laminated and very massive varieties. Some specimens show glossy muscovite along the bedding which is the schistosity direction and some have a lineation across the schistosity.

Specimen 7385 from just north of the Hydro-Electric Commission Hut on the Mersey is a white saccharoidal quartzite with feldspar visible as tiny white spots. It is a fine-grained quartzite consisting chiefly of quartz but with about 10-15 per cent of xenoblastic albite and some fine muscovite. The quartz shows a distinct preferred orientation with some elongation parallel to the schistosity marked by parallel muscovite flakes. The albite is lenticular to tabular in shape with the C-axis tending to be parallel to the schistosity.

Dove Schist

Although these rocks do not occur within the mapped area they outcrop well along the Forestry Road on the east side of the Mersey, north of its junction with the Fisher, and a few of the characteristic features are described.

This formation is a very thick mass of mica schist with garnet and albite in varying amounts and contains very little quartzite. Lithologically the rocks show a strong resemblance to the schists of the Howell Group.

Typical is 7370, a fine-grained, dark-grey, knotted, glossy schist. In thin section it is schistose with alternating thin layers rich in quartz and muscovite. Small porphyroblasts of garnet occur with larger ones of albite. There are sheafs and flakes of chlorite, much athwart the schistosity. Accessories are tourmaline and iron ore.

No. 7382 is an excellent example, and differs from 7370 in containing biotite, much of it growing along a second cleavage which is sporadically developed at about 35° to the major schistosity. In No. 7372 and others, the bedding plane schistosity is crenulated and a second fracture cleavage is developed across the tightly squeezed limbs of the tiny folds.

Thermal Metamorphic Rocks

The Devonian granite intrudes along the unconformity between the Dove Schist and the Ordovician quartzite on the Mersey River and here some schist has been hornfelsed. These rocks clearly show the effects of thermal metamorphism superimposed upon regional, e.g., 7384, 7377.

These are dense, reddish-brown rocks with a vitreous lustre and a hackly fracture. A thin section shows the original compositional layering to be present but the schistosity has been obliterated by the random growth of large quartz, muscovite and biotite crystals. There are numerous round and prismatic masses of very fine sericite and these are clearly pinite pseudomorphs of some metamorphic mineral which from the form is presumed to be andalusite. As these pseudomorphs only appear immediately next to the granite, the andalusite would be a thermal not regional metamorphic mineral.

Permian Rocks

These are flat-lying generally unmetamorphosed clastic sediments most of which have marine and glacial affinities. The basal rocks on the Forth River west of the February Plains are unusual and so will be described in some detail.

Specimen 7322 is from 50 feet above the base of the Permian in the Forth River and is a tough, massive, white, non-friable sub-greywacke sandstone with mica flakes visible in the hand specimen. It is composed of 70 per cent of quartz, 5 per cent muscovite and a little biotite and iron ore and 25 per cent of fine-grained clay matrix which has been recrystallized by the adjacent dolerite to a mesh of interlocking flakes. The quartz grains average ·25 mm. in diameter and are angular but with a medium to high sphericity. The muscovite flakes range up to ·5 mm.

The matrix of the underlying conglomerate is very similar and this rock has also been baked by the overlying dolerite sill which is only 200 feet away. The conglomerate is characterized by containing abundant well-rounded quartzite and schist pebbles with a high sphericity. The quartzite pebbles are peculiar in that a high proportion of them show small circular depressions about 1 cm. across on their smooth surfaces. These depressions were also found in pebbles from this horizon below Western Bluff, about 10 miles to the north-east.

The Permian beds in the south-western portion of the Arm Valley are tabulated elsewhere but one particular rock is distinctive and is described in detail here.

Specimen 7361 is a light-grey sandstone with a calcite cement which forms crystals over a centimetre across, enveloping the clastic grains; the crystals reflect the light giving bright flashes. It is composed of angular fragments between ·2 mm. and ·5 mm. across of quartz (50 per cent) plagioclase (10 per cent) muscovite flakes and rock fragments (slate 10 per cent, schist 10 per cent, chert and basaltic rocks) with a calcite cement comprising 15 per cent of the rock. The plagioclase is an acid andesine such as would be derived from the Devonian granites and some grains have been partly or wholly replaced by authigenic calcite. The calcite enclosed the grains with a seive structure and apparently has completely replaced an original clay matrix. The apparently high degree of sorting is due to the replacement and disappearance of the smaller particles. The rock is a sub-greywacke with a structure somewhat like that of a Fontainbleu Sandstone due to the addition of calcite by the adjacent dolerite.

Tertiary Volcanics

The volcanic rocks are chiefly basalts with pyroclastics occurring in the north-west of the area.

Pyroclastics

The thickest (400?) feet pyroclastic is a very coarse volcanic breccia which outcrops from 2000 feet to 2400 feet on the eastern side of the Forth River just below the Berriedale Plains and one mile north-east of Gisbourne's Hut. It is the movement of this material which resulted in the landslides covering the whole of the hillside. The breccia contains blocks and bombs of basalt and tachylyte up to three feet across, with the majority being about six inches in diameter. Many of the fragments are scoriaceous and the rock is loosely compacted and partially cemented with zeolite.

This breccia occurs on both the east and west sides of Gad's Hill on the road from Liena to Lorinna and appears to be confined to the centre of the pre-basaltic river valley.

Further up this valley, where it intersects the northern side of the Arm, the pyroclastics are thinner and finer grained, and on Magg's Mount they seem to be absent.

The tachylyte tuff 7411, from the north side of the Arm, is rather weathered, with dark glassy fragments in a clay-rich cement. A thin section shows that the particles are tachylyte containing crystallites, cemented by opal, calcite and a ferruginous weathering product.

Basalts

The basalts occur as flows varying from about 25 feet to 150 feet in thickness and reach a maximum total thickness of 350 feet and possibly 440 feet on the Berriedale Plains. They vary from dark-grey to black in colour when fresh but become light-grey and brown when weathered. Most are fine-grained and massive but some are completely scoriaceous and others are massive with a scoriaceous top. Jointing is chiefly in a rectangular prismatic form but a few flows show a platy flow structure; some have regular hexagonal prisms about 18 inches across. One variety which occurs in situ on the southern end of Magg's Mount and as large masses on the top and sides of Magg's Mount shows a strong development of curved and twisted columns from 6 inches to 12 inches across, with the columns commonly horizontal.

From a petrological examination of 30 thin sections it appears that there are four chief types.

The most common variety is a *porphyritic olivine basalt with black "glass"*, e.g., 7353, 7350, 7340, 7332, 7327, 7335, 7354, 7342, 7356, 7346. This type has olivine phenocrysts (5 to 20 per cent) averaging 1·5 mm. across, but ranging from ·5 mm. to 2·5 mm., in a fine-grained groundmass of pyroxene, plagioclase and black "glass", showing intergranular structure or a parallel flow structure, e.g., 7332. There is generally 5 per cent of brown and green or even orange opal and some calcite and chalcedony either as amygdale fillings or as intergranular patches. The olivine is almost invariably partially or wholly pseudomorphed by a brown carbonate which has the optical properties of magnesite or calcite. The proportions of pyroxene and plagioclase vary, depending on the amount of glass present, but they each constitute from 30-50 per cent with the pyroxene in excess of plagioclase. The plagioclase usually forms small laths about ·2 mm. long but may form phenocrysts up to 2 mm. across; it shows twinning on the Albite or Albite plus Carlsbad laws and is labradorite varying in composition from Ab_{42} to Ab_{50}. The pyroxene is pale-green to colourless with a low 2V around 35° and is generally from ·05 to 2 mm. across, but reaches 2·5 mm.

The black "glass" fills the intergranular spaces and consists chiefly of tiny closely packed granules and rods of opaque iron oxide. Between this is visible in some rocks a green isotropic material, presumably glass, e.g., 7340, in others is a dense aggregate of tiny pyroxene microlites and in others, e.g., 7357 there are crystallites of plagioclase and pyroxene.

The second type is the *porphyritic olivine basalt without glass*, e.g., 7358, 7333, 7329. These differ chiefly from the previous group in lacking the black glass, but in addition appear to contain a little less olivine (10 per cent) which is generally unaltered, and flow structure is more abundant.

The third type is the *semi-ophitic basalt*, e.g., 7325, 7409, 7355, 7339, 7326 and 7341. These rocks are rather fine-grained with phenocrysts of olivine in a groundmass of pyroxene, plagioclase, a little glass, opal and calcite. Pyroxene is abundant (up to 60 per cent) and forms crystals from ·2 to 1·2 mm. across or aggregates of granules up to 2 mm. across enclosing laths ·2 mm. long of plagioclase in an ophitic manner. The plagioclase usually does not exceed 35 per cent and forms small crystals with sporadic phenocrysts up to 2 mm. long. The pyroxene is pale-green to colourless and is characterized by having a low 2V, measurements ranging from 30° in 7339 to 40° in 7335. Olivine phenecrysts (5-20 per cent) range up to 1·5 mm. across and are mostly fresh with some alteration to carbonate or opal in a few specimens. One example (7325) contains up to 15 per cent of brown opal; another (7339) contains yellow and green opal, chalcedony and dark glass; 7355 shows amygdales with a lining of opal and a core of calcite and contains black "glass".

The fourth type is a *glomeroporphyritic basalt*, e.g., 7343, 7345, 7332, 7344. These are glomeroporphyritic in texture with large (3·5 mm.) aggregates of pyroxene crystals (·5 mm. across) and phenocrysts of plagioclase (up to 3 mm.) in a holocrystalline groundmass of pyroxene and plagioclase. Olivine is generally not present but there is very little, completely altered olivine in some specimens. Glass is lacking and there is usually about 10 per cent of brown opal or chalcedony. Amygdales (e.g., 7345) have a rim of opal and a centre of calcite. The plagioclase ranges in composition from labradorite Ab_{45}-Ab_{32}.

The distinguishing characteristics of the four groups are summarized below.

The chemical analysis of the four main types in table I show so few differences that the reasons for the marked textural differences between the flows are not clear. One significant fact is that of the porphyritic olivine basalts, those containing glass have three per cent more silica than those without and thus the glass must be rich in silica and perhaps is opaline. The lack of olivine in the glomeroporphyritic variety may be attributed to the fact that it contains about two to three per cent less magnesia than the other basalts.

The next specimens (2760 feet Forth, 2780 feet Arm and 2765 feet Magg's Mount where it is the highest flow) are all *semi-ophitic basalts* and thus could be the same flow.

Beneath these in the three sections are *porphyritic olivine basalts*. No. 7333 at 2700 feet on the Forth lacks glass but otherwise all are similar and we may correlate the specimens on the Forth ranging from 2700 feet down to 2500 feet with those on the Arm at similar heights and on Magg's Mount with rocks collected at 2765 feet, 2740 feet and 2710 feet (lack of outcrop prevented collection of specimens just below this).

The *porphyritic olivine basalt* at 2500 feet on the Forth may be correlated with the lowest flow found, at 2525 feet, on Magg's Mount.

The lowest flows before the underlying breccia is met, on the Forth section, are glomeroporphyritic, and outcrop at 2490 feet and 2460 feet. These are below the base of the basalts on Magg's Mount, but there is at least 50 feet of *glomeroporphyritic basalt* (No. 7345) on the Arm section at about 2500 feet.

A lower *porphyritic olivine basalt* (No. 7352) occurs in the Arm section at about 2300 feet and is the lowest found.

	Porphyritic olivine basalt with glass	Porphyritic olivine basalt	Semi-ophitic basalt	Glomeroporphyritic basalt
Texture	Intergranular and Porphyritic		Semi-ophitic	glomeroporphyritic
Olivine	Common			lacking
Alteration of olivine	to carbonate		fresh	
Glass	Black	lacking	brown to black	lacking
Chemical Analyses	(Analyst W. St. C. Manson)			
	(No. 7335)	(No. 7329)	(No. 7339)	(No. 7345)
SiO_2	49·58	46·66	49·48	49·80
Al_2O_3	13·69	13·06	13·32	14·25
Fe_2O_3	3·52	2·10	3·20	3·38
FeO	8·34	9·87	9·14	7·70
CaO	8·52	10·33	8·62	9·78
MgO	8·46	9·11	8·18	5·79
Na_2O	2·47	2·65	2·70	2·96
K_2O	0·59	0·91	0·71	0·93
H_2O	1·29	1·02	1·18	0·71
H_2O—	1·86	0·88	1·52	1·69
CO_2	—	1·02	—	—
MnO	0·18	0·18	0·16	0·13
TiO_2	1·69	1·77	1·66	2·05
P_2O_5	0·23	0·34	0·24	0·34
	100·42	99·90	100·11	99·51

One of the purposes of the petrological examination was to endeavour to correlate flows between the Forth, Arm and Mersey Rivers and despite the fact that the basalts do not differ much in composition it has been found to a certain extent possible to correlate the flows using the textural criteria.

The highest flow (2780 feet to 2810 feet) of the Forth section is similar to the highest (2820 feet) of the Arm section in that they are *porphyritic, olivine basalts* but the Forth rocks contain up to 10 per cent glass whereas the Arm rock has none.

Lack of definite correlation is due to the fact that all individual flows could not be recognized and sampled in each area, and all that was done was to collect from every flow recognized, or at 50 feet vertical intervals, whichever was the lesser distance. Differences in height between specimens collected from one flow at different localities is probably due to sampling at different levels in thick flows.

As far as can be determined, the flows are horizontal, as the contact between the upper two flows is at 2770 feet at the Forth and 2760 feet at Magg's

Mount four miles away. This suggests a very slight descent to the south implying that the lavas may have flowed upstream, but the difference is of the same order as the error in height determination by barometer and thus is not regarded as being significant.

There is a similar difference between the similar lavas at the Forth River (2500 feet) and Magg's Mount (2525 feet).

The following general sequence holds quite well for the three sections:

50 feet glomeroporphyritic basalt (top)
250 feet porphyritic olivine basalt
20 feet semi-ophitic basalt
60 feet porphyritic olivine basalt (base)

Pleistocene Till

Introduction

The following investigation was carried out on a specimen of till taken from the 40 feet high river terrace on the western bank of the Mersey, half a mile north of the Hydro-Electric Commission hydrographic hut and 15 feet above river level. The till is variable and this specimen may not be characteristic of all the till although it was chosen as a typical specimen. The sediment is tough and well consolidated; it lacks bedding and comparatively speaking is not friable. The references to toughness and non-friability are comparative as the rock is well lithified for Pleistocene material and is tougher than most Tertiary sediments but is inferior to most unweathered Permian and Triassic sediments.

The till consists of pebbles of all sizes (up to many feet in diameter) commonly several inches across, set in a matrix of sand and silt. Both the cumulative curve and the histogram indicate it to be very poorly sorted. The first and third quartiles are spread over 6·24 Wentworth grades. The histogram is bimodal and there is very little clay and silt present. The larger particles are of dolerite with a little quartzite; the sand is of fine-grained dolerite, quartz, pyroxene and feldspar; the silt of quartz, pyroxene and plagioclase. The particles are fresh and unweathered, and of low roundness and sphericity.

The mechanical analysis was carried out by using seives and the pipette method on the disaggregated material.

Analysis of the Individual Fractions

Each of the fractions was analysed under the binocular microscope as far as possible. In the fractions with a grain size greater than 0·5 mm. the material consists of rock fragments while those with grain sizes less than 0·5 mm. are composed mainly of individual crystals. In all cases in which the fragments are crystal aggregates, dolerite is the main rock type (usually 70 per cent), the rest consists mainly of quartzite with an occasional fragment of mica schist. In the finer fractions, pyroxene (augite and pigeonite) makes up about half the total while the rest is composed of feldspar (plagioclase) and quartz with a little magnetite and muscovite. The rock fragments are usually angular to sub-rounded with the sub-angular fragments predominating. Some pebbles have distinct flat surfaces (facets?) while there are several dolerite pebbles which are flat slivers.

Size	No. of particles examined	Composition, Roundness
+1″	6	Dolerite, 1 very well rounded, 1 sub-rounded, 4 angular
—1″ + ¾″	6	angular dolerite (67%)
	2	angular quartz-mica schist (22%)
	1	angular quartzite (11%)
—½″ + ⅜″	56	angular to sub-angular dolerite (71%)
	22	angular, white and grey quartzite (28%)
	1	sub-angular, quartz schist (1%)
—⅜″ + ¼″	200	angular to sub-rounded dolerite (71%)
	74	angular quartzite (27%)
	3	quartz mica schist (1%)
	3	angular basalt (1%)
—6·35 mm.		
+4·72 mm.	145	angular to sub-angular dolerite (few basalt?) (70%)
	59	angular quartzite (27%)
	6	quartz muscovite schist (3%)
—4·72 mm.	358	angular to sub-rounded dolerite fragments (75%)
+2·06 mm.	108	white, pink, grey angular quartzite fragments (23%)
	10	quartz muscovite schist—usually cleavage flakes (2%)
—2·06 mm.	202	angular to sub-rounded dolerite fragments (74%)
+1·68 mm.		
	58	white angular quartzite fragments (22%)
	15	grey cleavage flakes of quartz mica schist (4%)
—1·68 mm.	267	sub-angular to sub-rounded dolerite fragments (69%)
+1·005 mm.	108	angular to sub-angular quartzite fragments (29%)
	6	quartz mica schist cleavage flakes (2%)
—1·005 mm.	93	sub-angular to sub-rounded dolerite fragments 10 of which consist essentially of plagioclase with a small amount of pyroxene (80%)
	19	white to pink quartzite fragments (17%)
	3	quartz mica schist cleavage flakes (3%)

Bromoform Separation

An approximate modal analysis of the finer fraction using a bromoform separation and a grain count under the binocular microscope is as follows:—

plagioclase 48%
pyroxene 39%
quartz 11%
muscovite 1%
iron ore 1%

Heavy Fraction

This fraction consists dominantly of pyroxenes which are generally a pale translucent yellow-brown and rarely almost colourless. Commonly the crystals are encrusted with white earthy material (clay?). On clear faces the lustre is resinous to sub-vitreous while the cleavage is generally not obvious, although many fragments have cleavage faces. Under the microscope a very fine twinning in one direction was observed on many grains. Most fragments show only slight alteration but the extent is quite variable. The pyroxenes are biaxial positive with a 2V ranging from nearly zero to about 60° and thus it is considered that both pigeonite and augite are present, the actual proportions of each being difficult to determine. Due to the lack of centred figures and the presence of two different pyroxenes it was found that accurate refractive indices could not be obtained. The range of the refractive indices measured was from 1·690 to 1·715.

Magnetite comprises perhaps 2 per cent of the heavy fraction. It is opaque (black) and present both as distinct crystals (octahedra) or as irregular grains.

A few fragments of pale-green material (possibly olivine) occurred in the heavy mineral fraction.

Light Fraction

The light fraction consists of plagioclase, quartz and muscovite and in a count of 180 grains 80 per cent of them were plagioclase, 18·5 per cent quartz with the remaining 1·5 muscovite.

The feldspar occurs as opaque white to translucent laths having a sub-vitreous lustre on fresh faces. Alteration resulting in turbidity of the fragments is commonly present. Two cleavages, approximately at right angles are developed and albite twinning is present. In the majority of cases the refractive indices lie in the range 1·550-1·570 indicating a plagioclase of labradoritic composition. Several fragments of plagioclase were recognised with one RI = 1·5295 and another less than 1·5295 and from these it is inferred that the fragments are albitic in composition.

Conclusions

Assuming the quartz and muscovite came primarily from the Precambrian rocks the remaining constituents recalculated to 100 per cent are:—

plagioclase 54·5%
pyroxene 44·3%
iron ore 1·2%

This corresponds to the mode of dolerites quite well, allowing for the absence of the mesotasis, which would break down very easily and would have a finer grain than this fraction. The calculated mode therefore supports the results obtained in the coarser fractions that the greater part of the sediment resulted from the break down of dolerite.

From both the histogram and cumulative curve it can be seen that there is a considerable spread of sizes. There is about 80 per cent of the total in the pebble, granule and sand grades with the silt and clay grades comprising only about 20 per cent. These facts are brought out by the statistical treatment of the curves also. Thus the geometric quartile deviation (the ratio between the quartiles) or sorting coefficient (S_0) is 8·87. A value of S_0 less than 2·5 indicates a well sorted sediment, a value of about 3·0 indicates a normally sorted sediment, while a value greater than 4·5 a poorly sorted sediment. Thus a value of 8·87 indicates a very poorly sorted sediment which bears out the direct observation from the curves.

This result can be better visualized by application of the phi scale to the quartile deviation. Thus in this sediment the first and third quartiles are spread over a distance of 6·24 Wentworth grades and consequently the curve is decidedly drawn out. Krumbein and Pettijohn (1938) cite an example of a glacial till in which the spread is 4·9 Wentworth grades.

Thus it can be seen that the sediment is very badly sorted. The histogram it bimodal but not distinctly so; one mode lies in the pebble range and the second in the fine sand grade. From the results given above, therefore, the sediment may be glacial till but the small amount of material in the silt-clay grades is surprising. This may be explained by the fact that the material was derived from hard crystalline rocks and not much rock flour was produced.

Although the degree of sorting is not unlike that of some river gravels, the composition (particularly its content of fresh, sand-silt size pyroxene and plagioclase) is quite different.

STRUCTURE

Regional Structure

The regional structure here is similar to that shown near Deloraine, Tullah and Frenchman's Cap, i.e., around the edge of the Precambrian nucleus. The Precambrian rocks are regionally metamorphosed and show a pronounced bedding-plane schistosity and a lineation which is parallel to the axes of broad folds. The axes of these folds are parallel to those in the overlying lower Palaeozoic sediments which are generally unmetamorphosed. An angular uncomformity between the Precambrian and Palaeozoic rocks does not occur in most places despite the fact that there was a period of considerable metamorphism and deformation before the deposition of the Dundas Group.

The Cambrian is missing against the nucleus and a sandstone facies of the Ordovician overlies the Precambrian and is followed by the Ordovician Gordon Limestone. In this area (as near Tullah)

there is a granite with a lithology similar to the Devonian granites, intruded along the unconformity between Precambrian and Ordovician rocks.

The lower Palaeozoics are folded with the same trend as the Precambrian. In the core of the first major anticline away from the nucleus, thick Cambrian sediments and volcanics of the Dundas Group occur and in this zone the lowest Ordovician is represented by a very thick Owen Conglomerate. The lower Palaeozoics here are strongly deformed and tend to be over-folded and thrust towards the Precambrian nucleus.

The similarity in dip of the Precambrian and Lower Palaeozoic rocks across the unconformity and the parallelism of the fold axes in rocks of both ages indicates that the major part of the folding in the Precambrian occurred simultaneously with that in the Palaeozoics during the Tabberabberan Orogeny .

The Precambrian rocks are regionally metamorphosed and thus there was a period of metamorphism and orogeny before the Palaeozoic. Before the Tabberabberan orogeny, the Precambrian rocks would have been sub-horizontal with a schistosity parallel to the bedding and a pronounced lineation parallel to broad folds which were increased in amplitude during the Tabberabberan.

The faulting is closely related in direction to the fold axes and the major faults are probably high-angle reverse types.

Folds

The major structure in the Precambrian rocks is a synclinorium which plunges at about 20° in a direction 100° and this is named the Mersey Syncline. There is a major anticline (named the Fisher Anticline) which has a faulted axis, running parallel to that of the Mersey Syncline and which crosses the Mersey River about half a mile north of its junction with the Fisher. The general synclinal form is complicated by minor folds of all sizes and these may be grouped in the following way. The synclinorium is the first order fold about 10 miles across. There are second order folds about a quarter of a mile across. Third order folds about 10 to 100 yards across are quite common. The fourth order folds are small, apparently incongruent flow folds looking like strongly distorted drags about one foot across. The fifth order is represented by fine crenulations which extend down to microscopic dimensions.

The thick, massive quartzites usually show only first and second order folds and one example of the second order occurs about half a mile north of the Arm-Mersey junction; the thin quartzites and interbedded quartzites with slate or schist show second, third and fourth order folds. Third order folds are common in the Magg's quartzite north of the Hydro-Electric Commission hut. Fourth order folds are excellently shown by schist and thin quartzite of the Howell Group half a mile south of the Hydro-Electric Commission Mersey hut; fifth order folds are best shown by the slates of the Fisher Group and schists of the Dove and Howell group.

Foliation

The Precambrian rocks have been recrystallized during a period of regional metamorphism characterized by deformation which has impressed a strong schistosity on most rocks. It is, of course, less apparent in the quartzites which lack mica and is best developed in the slates and schists.

There are several completely different types recognizable and many of the rocks show two foliations. Most prominent is the schistosity which is parallel to the original bedding planes; this is produced by parallel muscovite flakes. There is considerable evidence in the schists that this is a direction of slip.

Many schists and quartzites show a second, poorly developed cleavage at about 30° to the bedding. This is due to the growth of late biotite and chlorite.

The third type of cleavage is developed at varying angles to the bedding in the slates of the Fisher Group. This is a "false" cleavage due to attenuation and close packing of the limbs of tiny asymmetrical folds where the bedding plane foliation has been crenulated.

Lineation

Lineation is well developed in most rocks, but particularly in the schists and quartzites of the Howell Group. It occurs as a streakiness of mica flakes on the schistosity plane, as a ribbing in quartzites or as a crenulation and is parallel to the axes of third order folds. The Arm Schist about half a mile south of the Hydro-Electric Commission hut, right on the track, shows a broad crenulation parallel to the axes of third order folds, together with a fine crenulation perpendicular to the axes.

The lineation commonly strikes parallel to the axis of the main fold but plunges flatly in the opposite direction, i.e., the fold plunges 20° towards 100 ° but the lineation is commonly plunging 30° towards 280°.

Faults

Three distinct sets of faults have been tentatively identified:—

(*a*) Major Precambrian, or Tabberabberan high-angle reverse (?) fault system trending at 280°;
(*b*) Minor sets of Precambrian or Tabberabberan transcurrent (?) faults trending at 315°;
(*c*) Possible set of Tertiary faults trending at 340°.

(*a*) It was seen here that the rocks on the opposite limbs of the major folds differed in character, particularly in the case of the Fisher Anticline. This has been repeatedly observed in many areas of Precambrian rocks in Tasmania and has been interpreted in the Frenchman's Cap area by Spry (1957) as being due to high-angle thrust faulting of large magnitude along the fold axes. If this is also true in this area, then there is a large fault striking at 275° half a mile north of the Mersey-Fisher junction. As there is a much larger width of outcrop of the Mersey Quartzite north of the major synclinal axis than there is to the south, it seems that a similar fault has removed part of the southern limb of the Mersey Syncline. On the northern limb of the Mersey Syncline, the

Fisher Group underlies the Arm Schist, but on the southern limb, the Howell Group lies below the Arm Schist. Various explanations are possible, e.g.—

(1) The Howell lies between the Arm and the Fisher but has been faulted out on the north limb;

(2) The Fisher lies betewen the Howell and the Arm and has been faulted out on the south limb.

(3) The Howell and the Fisher are equivalent.

Of these, the second alternative is preferred. The third is unlikely because, as is shown in the petrology and stratigraphy sections, there are very great differences between the Fisher and Howell Groups, and it is extremely unlikely that they are equivalent. The first is unlikely because the swing in strike of the Fisher-Arm contact between the Mersey and Forth Rivers makes faulting unlikely. These faults do not displace overlying Permian strata and are closely related in direction to folds in the Precambrian rocks and thus would be either Precambrian or Tabberabberan in age.

(*b*) The Fisher Group rocks on the east side of the Forth Valley, a mile south-west of Gisbourne's Hut appear to be cut by several faults trending at 315°. These cause considerable drag in a horizontal direction and are thus interpreted as transcurrent faults. It appears that the base of the Arm Schist is twice displaced for half a mile by these faults, but this cannot be proved at present because of the difficulty in locating the boundary between the Arm Schist and the Fisher Group.

(*c*) The dolerite of the February Plains, like that of the Plateau, is traversed by a prominent system of fractures which are clearly visible on the air photos. It was not possible to view these in the field but from their persistence and great length (8 miles maximum) it seems unlikely that they are merely tensional joints. The physiographic expression is simply a shallow, linear depression with no apparent topographic displacement or fault scarp. No displacement of the Permian sediments is visible on the air photos. It seems possible that they are Tertiary faults of very small throw and this could be verified by field observations where they cross the Permian rocks beneath the dolerite. They may well be persistent Tertiary shear joints with very slight horizontal movement.

Joints

Some Tertiary basalts show columnar jointing which may be divided into two types:—

(*a*) Normal, thick (2 feet across), hexagonal columns which are vertical and have parallel sides and cross-jointing which may be planar or ball and socket.

(*b*) Twisted, narrow (6 inches to 1 foot) columns which vary considerably in attitude and which do not have parallel sides, being fluted and irregular.

Apart from the possible shear joints mentioned above, the dolerite shows prominent joints on the air photos and these trend 310° and 350°.

The Precambrian rocks are well jointed in many directions but it was not possible to find much regularity. The small folds in the quartzites frequently show perfect joints normal to the fold axis ("ac") or vertical joints symmetrically disposed to the axial plane as shown in plate III.

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LOCALITY INDEX

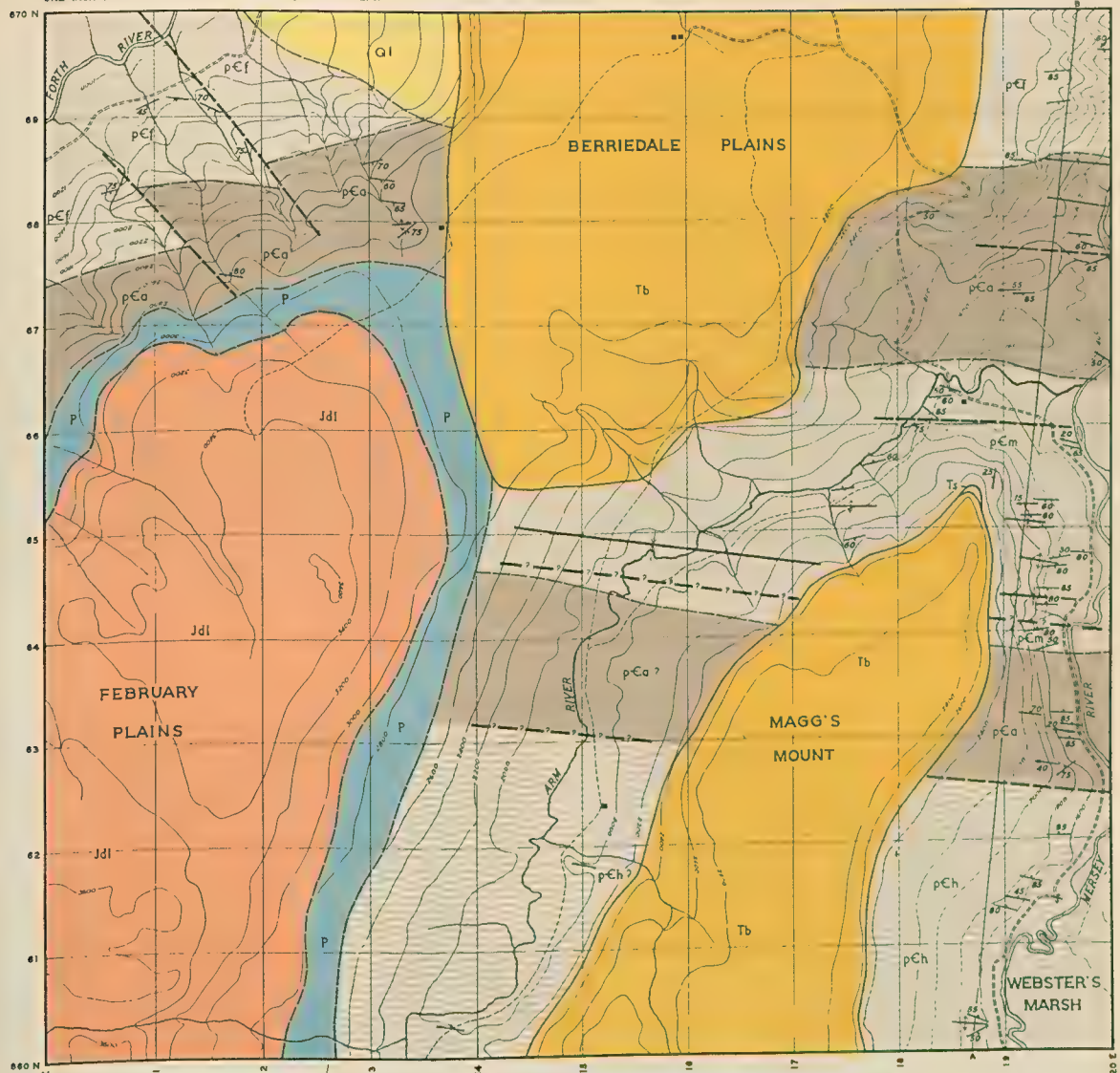
	Internat. Grid Reference K/55	S. Lat.	E. Long.
Arm River	Middlesex 45	41° 58′	146° 10′
Berriedale Plains	Middlesex 45	41° 40′	146° 8′
Cathedral Mountain	Ducane 52	41° 54′	146° 8′
Cradle Mountain	Mackintosh 44	41° 41′	145° 58′
Deloraine	Quamby 46	41° 31′	146° 40′
Devil's Gullet Ravine	Middlesex 45	41° 41′	146° 0′
Dove River	Mackintosh 44	41° 35′	146° 0′
Eldon Range	Murchison 51	41° 59′	145° 50′
February Plains	Ducane 52	41° 47′	146° 7′
Fish River	Ducane 52	41° 47′	146° 14′
Fisher River	Middlesex 45	41° 42′	146° 16′
Forth River	Sheffield 37 Middlesex 45	41° 25′	146° 15′
Frenchman's Cap	Pillinger 65	42° 17′	145° 50′
Gad's Hill	Middlesex 45	41° 33′	146° 10′
Gisbourne's Hut	Middlesex 45	41° 38′	146° 7′
Great Lake	Great Lake 53	41° 55′	146° 45′
Howell's Plains	Middlesex 45	41° 45′	146° 12′
H.E.C. Mersey Hut	Middlesex 45	41° 42′	146° 11′
Lake St. Clair	St. Clair 59	42° 4′	146° 10′
Lake Meston	Ducane 52	41° 52′	146° 15′
Liaweenee	Great Lake 53	41° 52′	146° 41′
Liena	Middlesex 45	41° 33′	146° 16′
Little Fisher River	Middlesex 45	41° 42′	146° 18′
Lorinna	Middlesex 45	41° 32′	146° 9′
Magg's Mount	Middlesex 45	41° 40′	146° 10′
Mersey River	Sheffield 37 Middlesex 45	41° 19′	146° 28′
Mole Creek	Middlesex 45	41° 33′	146° 25′
Mount Achilles	Murchison 51	41° 54′	145° 58′
Mount Dundas	Zeehan 50	41° 55′	145° 27′
Mount Oakleigh	Ducane 52	41° 50′	146° 3′
Mount Ossa	Ducane 52	41° 54′	146° 3
Mount Pelion	Murchison 51	41° 52′	146° 0′
Mount Pelion East	Ducane 52	41° 52′	146° 5′
Mount Pillinger	Ducane 52	41° 49′	146° 10′
Mount Roland	Sheffield 37	41° 28′	146° 16′
Pelion Wolfram Mine	Ducane 52	41° 58′	146° 2′
Rugged Range	Ducane 52	42° 46′	146° 16′
Table Mountain	Oatlands 68	42° 14′	147° 9′
Tullah	Mackintosh 44	41° 44′	145° 35′
Union Peak	Middlesex 45	41° 39′	146° 12′
Walls of Jerusalem	Ducane 52	41° 49′	146° 19′
Wentworth Hills	St. Clair 59	42° 13′	146° 19′
Western Bluff	Middlesex 45	41° 35′	146° 16′
Western Tiers	Lake River 54	41° 38′ to 42° 6′	146° to 147° 16′

GEOLOGY OF TASMANIA

ONE INCH SERIES — UNIVERSITY OF TASMANIA, GEOLOGY DEPT.

ARM RIVER

4186



LEGEND

- FORMATION BOUNDARY
- FORMATION BOUNDARY POSITION APPROX.
- FAULT PROBABLE
- FAULT INFERRED
- SYNCLINAL AXIS, FIRST ORDER
- SYNCLINAL AXIS, SECOND ORDER
- ANTICLINAL AXIS, SECOND ORDER
- DIP AND STRIKE OF STRATA
- PLUNGE OF LINEATION
- MOTOR TRACK
- FOOT TRACK
- HUT

Quaternary
- Qt — LANDSLIDE DEBRIS

Tertiary
- Tb — VOLCANICS
- Ts — SEDIMENTS

Jurassic
- Jdl — DOLERITE

Permian
- P — SEDIMENTS

Precambrian
- pCm — MAGGS QUARTZITE
- pCa — ARM SCHIST
- pCf — FISHER GROUP
- pCh — HOWELL GROUP

Compilation from Aerial Photographs.
Trigonometric Station Control by courtesy Lands and Surveys Department.
Origin of coordinates 400,000 yds. West and 1,800,000 yds. South of True Origin of Zone 7 of the International Grid.

MAPPED AND COMPILED BY A.H. SPRY 1956

KEY MAP SHOWING MAGNETIC DECLINATIONS SECULAR VARIATION 7' PER ANNUM

SCALE

0 1 2 3 4 5,000 — 2 MILES — 10,000 FEET.

GEOLOGY OF THE RIVER ARM AREA

Pleistocene Glacials covering approximately half of the area are not shown.

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2. STRATIGRAPHIC TABLE:

AGE	GROUP	FORMATION	LITHOLOGY	THICKNESS
Recent			Landslide debris	(?)
Pleistocene			Till, varves	160'+
		EROSION INTERVAL		
Tertiary			Basalt flows and pyroclastics	800'
		EROSION INTERVAL		
Jurassic			Dolerite sill	
Permian			Basal conglomerate, sandstone, siltstone	250'
		UNCONFORMITY		
		Magg's	Quartzite	2000'
Precambrian		Arm	Schist and Quartzite	3000'
	Fisher		Slates and Quartzites	5000'+
	Howell		Schists and Quartzites	5000'+

3. LOCALITIES OF SPECIAL INTEREST:

Pleistocene varves on Arm River	E414600.N862400
Minor folds in Arm Schist	E419400.N862700
Roche moutonnee	E419800.N866200
Tertiary basalt section	E41500.N86200 to E415600.N865500
Minor anticline	E419700.N861400

1

2

3

4

PLATE I

No. 1.—View from the Plateau near the Fisher River to the south-west. The flat surface in the centre is Maggs Mount with the February Plains beyond and Barn Bluff (right) and Mt. Pelion West (left) on the skyline.

No. 2.—Facing the dolerite scarp of the Plateau at Western Bluff from a point north of the intersection of the Mersey and Fisher Rivers. The flat in the foreground is the stripped pre-Permian surface.

No. 3.—Looking up the Arm River towards Mt. Pillinger. The flat plains are underlain by terminal-zone glacials of the Pleistocene.

No. 4.—The scarp between two terraces in the Mersey Valley, half a mile north of the H.E.C. hut.

1

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PLATE II

No. 1.—Pleistocene till overlying varves in the bank of the Arm River, three miles upstream from its junction with the Mersey.

No. 2.—Detailed view of the Arm River varves. The section is about three feet across.

No. 3.—Pleistocene till in a river terrace on the Mersey. A mechanical analysis is given in this paper.

No. 4.—Moraine-dammed lake on the Central Plateau to the south-east of this area.

1

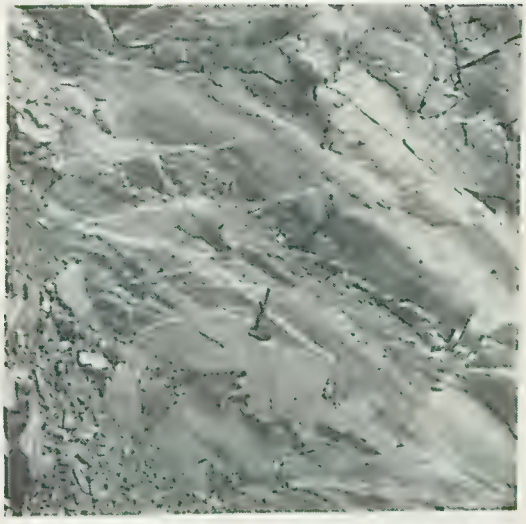

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PLATE III

No. 1.—Nearly vertical Precambrian quartzites in a gorge of the Forth River just north of Gisbourne's Hut.

No. 2.—Lineated quartzites of the Fisher Group at the Mersey-Fisher junction.

No. 3.—Quartzite in the Arm Schist at the rapids just north of Walters Marsh. Lineation (ribbing) is parallel to the axis of a minor anticline and joints are symmetrically disposed.

No. 4.—Conical shaped outcrop of Tertiary volcanic breccia on the slope from Berriedale Plains to the Forth River. An extensive landslide area begins at the base of this slope.

A NOTE ON THE IDENTITY OF THE TASMANIAN LITTORINID MOLLUSCS

By

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ABSTRACT

The molluscan genus *Melarhaphe* was investigated in relation to its two Tasmanian representatives and is discarded in favour of *Littorina*.

In the course of ecological investigations in Tasmania I have had much cause to examine the habit of the two species of littorinid which occur in Tasmania and it appeared to me that, although these two species are known as *Melarhaphe unifasciata* (Gray) and *M. praetermissa* (May) respectively, the habitat occupied by them was very similar to that usually occupied by the genus *Littorina*. This prompted me to investigate the genus *Melarhaphe*.

The genus *Littorina* was introduced by Ferrusac (*Tabl. Syst. des Moll.* 1822, p. 34) who designated *L. obtusata*, now known as *L. littoralis* (L.) as the genotype. The genus was immediately adopted and has been almost universally used ever since.

Melarhaphe was established by Menke (*Synops. meth. Moll.* 1828, p. 23) and he designated *M. neritoides* (L.) as the genotype. Thus, the genus *Littorina* is divisable into two groups of species, namely those with a reduced spire and the great majority with a high spire.

Iredale (1912), in adopting the genus *Melarhaphe* states "the type of Littorina is quite unlike the Austro-Neozelandic shells known under that name and the name to be used for those shells is *Melarhaphe*". He did not contrast the two genotypes or compare the Australian species with either genotype. The genus has been followed in Australia since 1912, there being only two Tasmanian species.

Iredale is undoubtedly correct in stating that *L. littoralis* is unlike any of the Austro-Neozelandic shells known under that name. It is equally unlike any of the European or American shells also known under the name of *Littorina*, being a shell of atypical littorinid form without the spire usually so characteristic of that family.

However it is very significant that the genus *Melarhaphe* was never followed in Europe. Even as early as 1835, Quoy and Gaimard were using the genus *Littorina* for shells which Iredale would consider to be assignable to *Melarhaphe*, e.g., *L. diemenensis*, i.e., shells with a high spire. The list of British marine mollusca (Conchological Society, 1902) does not include *Melarhaphe* but assigns the species *obtusata* to the genus *Littorina* and the Marine Biological Association (1931) follows this example. Moore (1937) uses *Littorina* for another high spire species *L. littorea* (L.). Other modern workers use *Littorina* exclusively and Simroth (in Bronn's *Klassen und Ordnungen des Tierreichs*) and Thiele (in Kukenthal's *Handbuch der Zoologie*) do not include *Melarhaphe* as a valid genus in the family *Littorinidae*.

Turning to the two Tasmanian species *M. unifasciata* and *M. praetermissa* we find that they are of the high spire type, i.e., resemble *L. neritoides* of Europe. I have examined the radulae of several specimens of *M. unifasciata* and find them closely to resemble that of *L. littoralis* and the Tasmanian shells fit into the genus *Littorina*. In view of these facts and also on account of *Melarhaphe* being discarded by overseas workers I propose to adopt *Littorina* as the generic name of the two Tasmanian shells hitherto known as *Melarhaphe*, thus following the usually accepted interpretation of the genus *Littorina*.

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PAPERS AND PROCEEDINGS OF THE ROYAL SOCIETY OF TASMANIA, VOLUME 92

NATURAL HYBRIDS IN EUCALYPTS, PART I.

E. X taeniola (= *E. salicifolia X E. sieberiana*)*

By

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(WITH 3 TEXT FIGURES)

ABSTRACT

Progeny tests of open pollinated seed from *E. sieberiana* F. v. M., *E. salicifolia* (Sol.), Cav. (syn. *E. amygdalina* Labill.) and the presumed hybrid form *E. X taeniola* B. & S. (pro sp.), from natural populations are described. The variation in juvenile leaf size and shape in progenies of the *taeniola* form, confirms the suggestion that this is a hybrid between the above species.

Individuals, intermediate in form between *E. sieberiana* and *E. salicifolia*, were collected by L. Irby from the slopes of St. Patrick's Head, Tasmania. These were given specific rank by Baker and Smith (1912), although affinities with the above species were recognized. Baker and Smith's ranking was recognized by Blakely (1934) in his "Key to the Eucalypts". In his survey of the Tasmanian species Brett (1937) classified *E. taeniola* as an interspecific hybrid. He stated that there was every indication that *E. taeniola* was a hybrid between *E. sieberiana* and *E. salicifolia*, adding without further qualfication that the hybrid character was evident at the cotyledon stage. The specific ranking was accordingly dropped by Curtis (1956).

A study of the natural populations of *sieberiana* and *salicifolia* supports Brett's view as to the hybrid nature of the *taeniola* forms. These are found only within the limits of the *sieberiana* distribution on the East Coast, between St. Helens and Oyster Bay, extending westward to Rose's Tier. The *taeniola* form is found only as isolated trees, although the *salicifolia* within this area exhibits considerable variation.

The more important diagnostic characters of the seed parents are listed in Table I. Typical leaves and fruits are represented in fig. 2. Most *taeniola* specimens show intermediate bark characters, tending usually towards the *salicifolia* type. The mature leaves, although wider and more falcate than those in *salicifolia*, also tend towards this species rather than to *sieberiana*. In buds and fruit the *taeniola* form closely resembles *sieberiana* with pyriform fruits and sunken discs.

To establish some experimental evidence of the hybrid nature of the *taeniola* form, seedlings were raised from open pollinated mother trees from the natural population. This seed was collected by Professor H. N. Barber at Bicheno in February, 1952. The presumed parental types *E. sieberiana* and *E. salicifolia* were represented by progenies raised from parents growing in the same locality. Two seed parents of each type were used. However, the progeny size in one of the sets (set 2 below) was restricted because of limited propagation facilities.

Seed set and viability in the *taeniola* form did not differ markedly from that in the parental types. Seedlings were raised under standard conditions in the glasshouse, pricked off into 6 x 1·5 inch veneer tubes after three weeks and after six months were propagated in 6 x 6 inch cans. When the seedlings were 12 months old five leaves of average development were removed from each, where possible from the 10th to 14th nodes inclusive. These leaves were measured for size and shape while fresh. Table II shows the progeny means and an anlysis of variance for leaf length, breadth, length/breadth ratio and petiole length for individual seedlings. The distribution of individual means is shown graphically in figure 1, while the range in leaf shape in the progeny of 21 plants raised from *taeniola* 1 is shown in fig. 3. In this plate leaves approximating most closely to the mean leaf for each seedling are shown together with average leaves from the two presumptive parent species.

Because of the non-orthogonal nature of the data the analysis of variance is somewhat tedious. It is here treated as a hierarchy of unequal numbers thus facilitating the grouping of components.

Leaf breadth, length/breadth ratio and petiole length are efficient classification variables. Length of leaf has a high coefficient of variation and is an unsuitable diagnostic. From the analysis of variance shown in Table II it is clear that the within-seedling variance in all progenies is small. The variance between seedlings is very much greater in the *taeniola* progenies than in the presumptive parental progenies, with the exception of the progeny *salicifolia* (2). Excluding length the variance ratios for the other three characters in the two *sieberiana* parents and *salicifolia* (1), are much lower than the variance ratios for the *taeniola* progenies and are about one-fifth those for *salicifolia* (2). The anomalous heterozygosity in *salicifolia* (2) is at once evident if the variance in parental groups is considered. With the exception of petiole length the between-parent variance and the variance ratios are disproportionately large in *salicifolia*. The variance ratios in

*Nomenclature is that of Blakely, 2nd Edition, 1955.

taeniola suggest that these parents may be grouped as presumptive F_1 hybrids although the between-parent variance indicates a considerable difference in genotype. *Salicifolia* (2) by its parental characters lies well within the *salicifolia* phenotypic range but the segregation in its progeny indicates that it should be classified as an F_2 or other close derivative. This can be confirmed to some extent by an analysis of variance after regrouping *salicifolia* (2) with *taeniola* (Table II). When this is done the homogeneity in the variance ratios between the groups is restored.

The range of variation in the characters on this grouping leaves no doubt as to the hybrid nature of the *taeniola* form. The range is transitional between the two parental types although it is weighted towards *salicifolia*. This gradation in segregating leaf characters is to be expected on the basis of a polygenic inheritance of leaf size and shape. The marked correlations evident in figure 1 indicate a strong dependence between these characters; a relationship which doubtless has its origins in the common members of the polygenic systems governing cell number and size.

The progeny testing of open pollinated parents thus provides reasonable justification for regarding the *taeniola* type as an interspecific hybrid between *E. sieberiana* and *E. salicifolia*. The fact that the *taeniola* form is restricted to the limited *sieberiana* distribution and that it occurs only as isolated trees is itself strong evidence for the classification of the form as a hybrid between these species.

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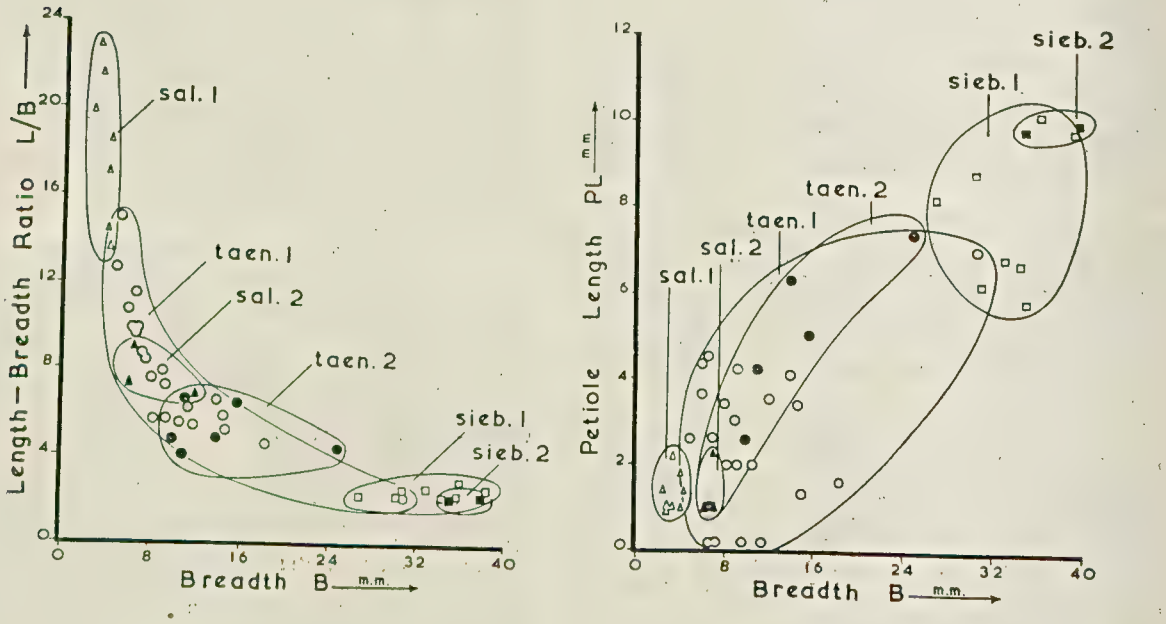

FIG. 1.—Scatter diagrams showing the relationship between juvenile leaf characters in progenies from parental and presumptive F_1 types. Each point represents the mean value for a seedling of measurements of leaves from the 10th to the 14th nodes inclusive.

TABLE I

Parental Characters

Parent	Bole bark	Limb bark	leaf length in cm.	leaf breadth in cm.	petiole length in cm.	fruit length in cm.	fruit diam. in cm.	carpel number x
Sieb. 1	deep fissured fibrous	clean gummy	20·1	1·8	1·9	11·4	7·7	3·0
Sieb. 2	deep fissured fibrous	clean gummy	18·7	2·4	1·7	12·4	7·8	3·1
Taen. 1	fissured flaky fibrous	clean gummy	13·2	1·0	1·4	10·2	6·4	3·5
Taen. 2	fissured flaky fibrous	clean gummy	17·2	1·6	1·1	9·3	5·8	3·1
Sal. 1	flaky fibrous	clean gummy	8·9	0·5	0·3	6·3	6·8	4·0
Sal. 2	flaky fibrous	thin flaky	9·1	0·8	0·8	6·9	5·7	4·7

TABLE II

Means, standard errors of means and the analysis of variance for the juvenile leaf characters, length L, breadth B, length/breadth ratio L/B and petiole length PL.

	L	B	L/B	PL	d.f.	L	B	L/B	PL	d.f.	L	B	L/B	PL	d.f.
	sieberiana 1					taeniola 1					salicifolia 1				
Progeny means	82·2	33·3	2·45	7·7	8	69·2	10·6	7·73	2·6	21	61·1	3·5	17·73	1·4	8
S.E. of means	12·6	2·1	0·55	0·1	....	5·7	0·7	0·61	0·1	....	2·7	0·7	1·49	0·4	....
Variance															
between seedlings	1281·1	72·8	0·35	16·6	7	634·4	169·8	47·18	18·9	20	419·2	1·5	79·03	0·9	7
within seedlings	74·9	21·8	0·08	6·6	32	93·2	3·0	1·59	0·8	84	41·1	0·5	11·65	0·1	32
Ratio F	17·1	3·3	4·4	2·5	....	6·8	56·8	29·7	23·4	....	10·2	3·2	6·8	6·3	....
	sieberiana 2					taeniola 2					salicifolia 2				
Progeny means	86·9	35·9	2·36	9·9	2	70·8	13·7	5·54	4·5	6	63·0	8·2	7·34	1·4	3
S.E. of means	10·5	4·2	0·00	0·0	....	24·0	5·7	1·83	2·2	....	48·6	4·3	2·24	1·6	....
Variance															
between seedlings	220·9	36·0	0·00	0·1	1	3458·0	202·8	20·17	29·9	5	1567·8	54·2	15·09	8·1	2
within seedlings	99·0	19·9	0·03	0·4	8	24·9	2·6	1·16	1·7	24	106·0	1·5	0·51	0·6	12
Ratio F	2·2	1·8	0·00	0·3	....	138·8	78·0	17·38	17·9	....	14·8	*36·1	*29·6	14·1	....
	sieberiana 1 and 2					taeniola 1 and 2					salicifolia 1 and 2				
Variance															
between parents	176·8	102·3	0·10	28·1	1	170·9	225·6	117·77	77·8	1	79571·0	238·4	1166·5	2·1	1
within parents	257·9	29·2	0·11	6·9	48	288·8	35·5	9·07	4·8	133	163·4	2·9	18·16	1·0	53
Ratio F	0·7	3·5	0·9	4·1	....	0·6	6·4	12·98	16·3	....	*487·1	*83·0	*64·2	2·2	....
	sieberiana 1 and 2					taeniola-salicifolia 2					salicifolia 1				
Variance															
between groups	176·8	102·3	0·10	28·1	1	12649·5	128·2	4·88	61·7	1	419·2	1·5	79·03	0·9	7
within groups	257·9	29·2	0·11	6·9	48	856·1	34·3	9·19	5·0	148	41·1	0·5	11·65	0·1	32
Ratio F	0·7	3·5	0·9	4·1	....	14·78	3·7	0·5	12·4	....	10·2	3·2	6·8	6·3	....

* anomalous variance ratios d.f. = degrees of freedom

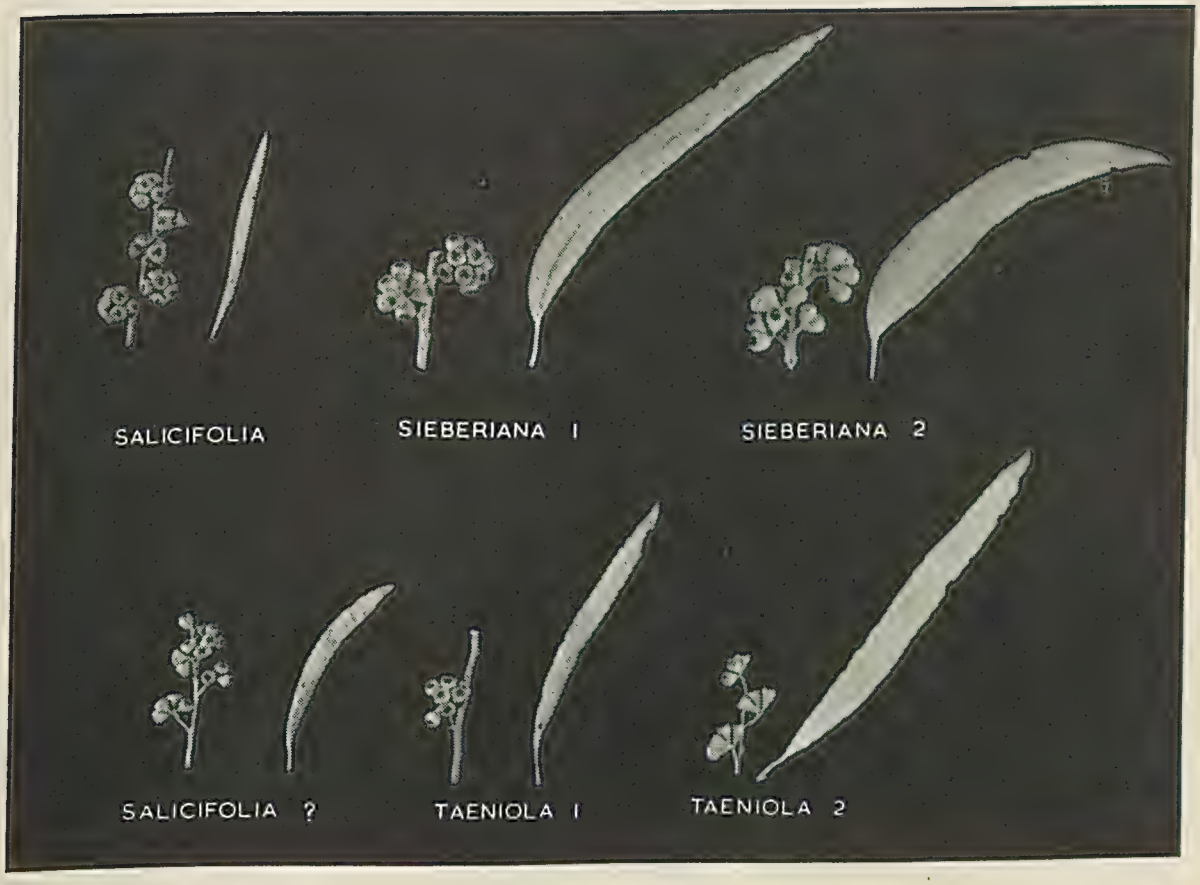

FIG. 2.—Leaves and umbels of fruit from the open pollinated seed parents used in the progeny tests.

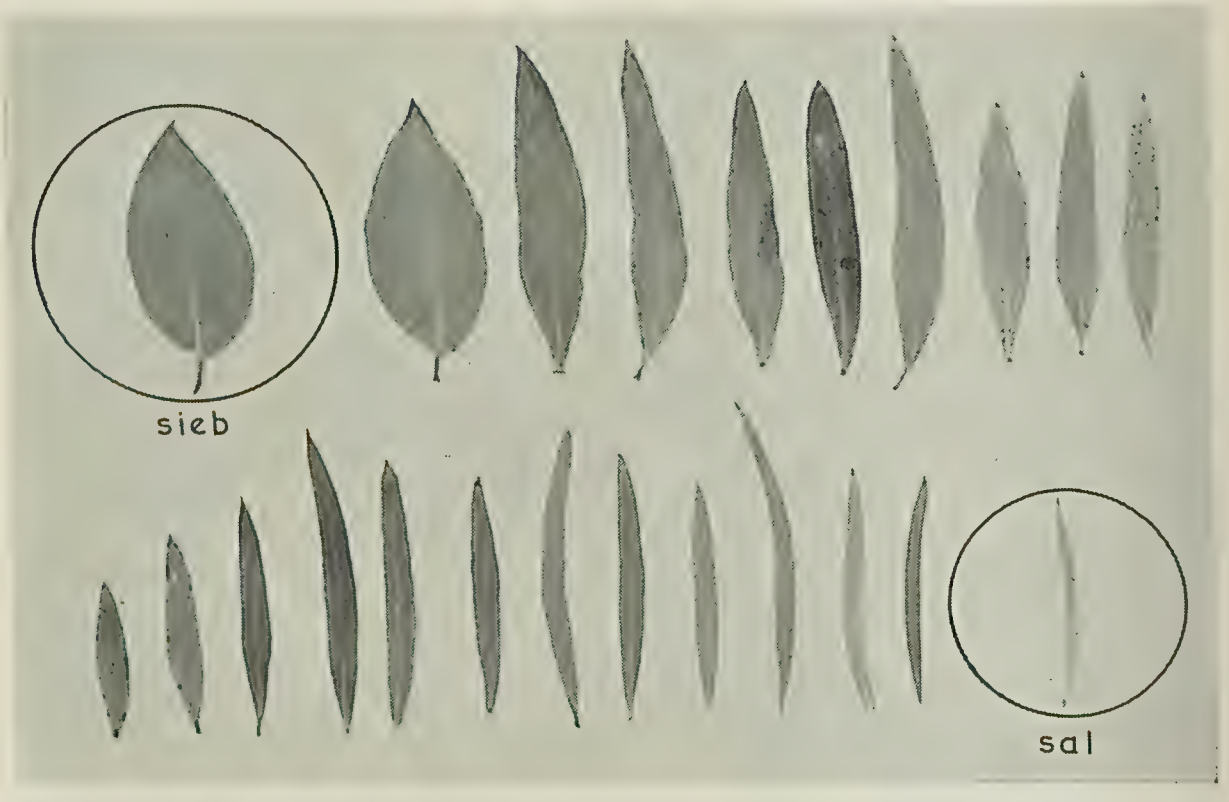

FIG. 3.—Representative leaves from each of the 21 seedlings of the progeny from the presumptive hybrid, *taeniola* 1, showing the transition between the parental types *sieberiana* and *salicifolia*, typical representatives of which are shown in circles. Each leaf is that closest to the mean of five leaves from the 10th to 14th nodes inclusive.

A NOTE ON SOME GREEN MICACEOUS MINERALS FROM TASMANIA

By

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(With 1 Text Figure)

A green translucent micaceous mineral of massive habit occurring at many mineralized zones in Tasmania has been examined in a preliminary fashion by the X-ray diffraction method. Specimens of this mineral are held at various institutions and have been called by different names. Those studied are listed below in Table 1.

Some samples from the Swansea Mine, Zeehan and Round Hill were seen at the Mines Department, Hobart, but were not examined by X-rays. An occurrence of similar material is recorded by Petterd from Blue Tier, North-Eastern Tasmania.

For this work, powder specimens were rotated in a 3 cm radius Unicam camera using Cu Ka radiation and no correction has been made for film shrinkage. Darkening of the film made measurement of lines greater than 9kX difficult but this could be eliminated by a change in method.

The "d" spacings and intensities (strongest lines only) are shown in Table 2 and indicate that all these specimens have similar X-ray patterns. As might be expected they do not exactly match the pattern for muscovite but are close to it and are very similar to the pattern given by the chrome mica from Calaveras County, California (2). The specimen from Moore's Pimple called pyrophyllite gives a pattern unlike those published for genuine pyrophyllites.

The batchelorite spacings are so similar to the others that the validity of naming this as a separate mineral must be questioned, and also suspect is the identification of the agalmatolite from Mt. Lyell.

The known association of the chrome micas with mineralized zones (Whitemore *et al* 1946) makes the consideration of the distribution as well as the study of the mineralogy of these minerals of interest and this note is published to draw attention to this problem.

LOCALITY MAP

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Kauffman, et al., 1950.—U.S. Bureau of Mines, Report of Investigation 4721.

Whitemore, D. R. E., Berry, L. G. and Hawley, J. E., 1946.—Chrome Micas. The American Mineralogist, Vol. 31, No. 1, p. 1.

Table 1

Name	No.	Locality	Storage	Collector
Batchelorite	1	Mt. Lyell	University of Tasmania	Mt .Lyell Mining Co.
Agalmatolite	2	Mt. Lyell	Tasmanian Museum	Mt .Lyell Mining Co.
Pyrophyllite	3	Moore's Pimple	Tasmanian Museum	....
Fuchsite	4	Rosebery	Tasmanian Museum	Taylor, Ford, Hale
Fuchsite	5	Mt. Lyell	....	W. Baker
Fuchsite	6	S. Comet Mine, Dundas	Tasmanian Museum	H. Bartlett
Fuchsite	7	Maydena	University of Tasmania	Banks and Hale

TABLE II

	(2) Agalmatolite		(5) Fuchsite (Mt. Lyell)		(4) Fuchsite		(1) Batchelorite		(6) Fuchsite		(7) Fuchsite		(3) Pyrophyllite		Chrome Mica	
	I	D	I	D	I	D	I	D	I	D	I	D	I	D	I	D
(1)*	S	9.30		..	S	9.8	VS	9.58	VS	9.84	VS	9.95	VS	10.06	VS	9.98
		..		5.03		7.02		..		..		..		7.56		..
(2)		4.93		..		4.94		4.58		4.65		4.98		4.96		4.94
(3)	VS	4.48	VS	4.48	VS	4.45	VS	4.39	VS	4.36	VS	4.45	VS	4.47	VS	4.44
		..		4.27		3.92		3.76		3.67		..		3.75		..
(4)		3.70		3.73		..		..		..		..		..		..
		..		3.51		..		..		..		..		..		..
(5)		3.49		..		3.46		..		..		..		..		3.63
(6)		3.30	VS	3.34		3.30		..	S	3.27	S	3.30	S	3.32	VS	3.30
		..		3.20		..		..		..		3.01		..		3.03
(7)		3.18		..		..	S	3.19		..		..		..		..
(8)	VS	3.05		3.00		..		..		..		..		..		..
(9)		2.95		..		..		2.94		2.94		..		..		..
		..		2.84		2.88		2.81		..		..		2.84		..
(10)		2.79		..		..		2.69		2.76		..		..		..
(11)	VS	2.55	VS	2.58	VS	2.56	VS	2.54		2.52	VS	2.56	VS	2.57	VS	2.55
		..		2.48		2.53		..		..		..		2.45		..
(12)		2.40		2.39		2.38		2.42		2.40		2.41		2.38		2.45
		..		2.22		2.21		2.21		2.33		2.21		2.22		2.37
(13)		2.14		2.15		2.13		2.12		2.10		2.12		2.12		2.13
(14)		2.05		2.08		..		..		..		..		..		..
		..		2.01		..		..		..		..		..		..
(15)		1.98		..		1.99		1.98		..		1.98		1.99		1.98
		..		..		..		1.91		1.95		1.89		..		1.94
(16)		1.83		1.74		1.80		..		..		..		..		..
(17)		1.69		1.66		1.65		1.69		..		1.69		1.65		1.65
(18)		1.63		1.61		..	VS	1.63		..		1.64		..		1.62
		..		1.57		1.55		1.56		..		..		..		..
(19)		1.52		1.53		..		..		..		..		..		..
(20)	S	1.48	S	1.51	S	1.50	S	1.49	S	1.48	S	1.50		1.50	S	1.49
(21)		1.46		1.46		..		1.44		1.42		..		..		..
		..		1.43		..		..		..		..		..		..
(22)		1.41		..		1.40		..		..		..		..		..
(23)		1.38 }		..		..		..		..		..		..		..
(24)		1.38 }		1.36		..		..		..		..		..		..
(25)		1.34		1.35		1.35		1.33		1.33		1.35		1.35		1.33
		..		1.31		1.30		..		..		1.30		..		..
(26)		1.28		1.28		..		1.29		1.28		..		1.28		1.29
(27)		1.26		1.26		..		..		..		..		..		..
(28)		1.23		1.23		..		1.24		1.23		1.25		1.24		1.24
(29)		1.21		..		..		..		..		..		..		..
(30)		1.15		..		1.18		1.18		..		..		..		..
(31)		1.11		..		..		1.11		..		..		..		..
(32)		1.09		..		..		..		..		..		..		..

* VS—Very strong
S—Strong

NEW RECORDS OF FISHES FROM THE SOUTH-EASTERN AUSTRALIAN CONTINENTAL SLOPE

By

T. R. Cowper*

(Communicated by A. M. Olsen, C.S.I.R.O., Hobart)

ABSTRACT

Centrophorus nilsoni Thompson and *Deania kaikourae* (Whitley) constitute new records for Australia; *Centrophorus scalpratus* McCulloch for Tasmania and South Australia, and *Rexea solandri* (Cuvier and Valenciennes) for South Australia.

INTRODUCTION

In the course of a deep-lining survey of the south-eastern Australian continental slope during 1950-1955, some species of fish were encountered which proved to be new records; two for Australia, two for South Australia, and one for Tasmania. This was not surprising since most of the fishing was conducted on previously unfished grounds and at depths normally beyond the range of commercial fishing gear.

CENTROPHORUS SCALPRATUS McCulloch

(Endeavour Dogfish)

Centrophorus scalpratus McCulloch, Zool. Res. Endeavour 3 (4), 1915, p. 97, pl. 13; Whitley, Fish. Aust. 1, 1940, p. 145, figs. 157-158.

Specimens examined: East of Eden, N.S.W. (33); East of Eddystone Point, Tas. (6); East of Cape Lodi, Tas. (1); East of Cape Forestier, Tas. (1); West of Stokes Point, Tas. (1); South of Port Fairy, Vic. (54); West of Kangaroo Is., S. Aust. (4).

Vertical distribution: 240-440 fathoms.

Length: 500-1160 mm. total length.

Weight: 2½ lb.-18 lb.

Range: Previously recorded from New South Wales and Victoria . Range now extended to include Tasmania and South Australia.

CENTROPHORUS NILSONI Thompson

(Nilson's Dogfish)

Centrophorus nilsoni Thompson, Rec. Cantab. Mus. N.Z., 3, 1930, p. 276, pl. 43.

Centrophorus (Somnispinax) nilsoni Whitley, Fish. Aust. 1, 1940, p. 146, fig. 160.

Specimens examined: South-west of Port Davey, Tas. (1).

Vertical distribution: 426-430 fathoms.

Length: 1280 mm. total length.

Weight: 26 lb.

Range: Previously recorded from deep water off Kaikoura, New Zealand. Range now extended to include Australia.

DEANIA KAIKOURAE (Whitley)

(Dorian Gray)

Centrophorus kaikourae Whitley, Mem. Q'land Mus. 10, 1934, p. 199.

Centrophorus calceus (non Lowe) Thompson, Rec. Cantab. Mus. N.Z., 3, 1930, p. 275, pl. 42.

Deania kaikourae Whitley, Fish. Aust., 1, 1940, p. 146, fig. 161.

Specimens examined: East of Eden, N.S.W. (1); East of Cape Lodi, Tas. (6); East of Cape Forestier, Tas. (8); East of Maria Is., Tas. (22); South of Pedra Blanca, Tas. (3); South-west of Port Davey, Tas. (3); West of Stokes Point, Tas. (8); West of Cape Wickham, Tas. (2); South of Port Fairy, Vic. (4).

Vertical distribution: 280-600 fathoms.

Length: 690-1150 mm. total length.

Weight: 4 lb.-16 lb.

Range: Previously recorded from deep water off Kaikoura, New Zealand. Range now extended to include Australia.

REXEA SOLANDRI (Cuvier and Valenciennes)

(King Barracouta)

Gempylus solandri Cuvier and Valenciennes, "Hist. Nat. Poiss." 8, 1832, p. 215.

Rexea furcifera Waite, Rec. Cantab. Mus. N.Z., 1, 1911, p. 236, pl. 52.

Rexea solandri Matsubara and Iwai, Pacif. Sci. 6 (3), 1952, pp. 203-207.

Specimens examined: East of Eddystone Point, Tas. (1); East of Cape Lodi, Tas. (11); East of Cape Forestier, Tas. (5); East of Maria Is., Tas. (3); East of Yellow Bluff, Tas. (4); East of Pirates Bay, Tas. (2); East of Cape Pillar, Tas. (3); South of Pedra Blanca, Tas. (2); South-west of South West Cape, Tas. (3); South-west of Port Davey, Tas. (2); West of Stokes Point, Tas. (1); South of Port Fairy, Vic. (3); South-west of Lacey Is., S. Aust. (1).

Vertical distribution: 180-440 fathoms.

Length: 670-910 mm., L.C.F.

Weight: 4 lb.-10½ lb.

Range: Previously recorded from Japan, New Zealand, New South Wales, Victoria and Tasmania. Range now extended to include South Australia.

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PAPERS AND PROCEEDINGS OF THE ROYAL SOCIETY OF TASMANIA, VOLUME 92

THE CRYOPLANATION OF MOUNT WELLINGTON

By

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(With 1 Text Figure)

ABSTRACT

Present morphology of the Mt. Wellington summit area can be interpreted in terms of a system of cryoplanation, which operated during the Pleistocene, but has now ceased. This involved the rapid frost shattering of exposed dolerite and the removal of this and previously weathered material by mass movement over slopes as low as 3°. Periglacial processes of land reduction were probably widespread in Tasmania during the Pleistocene and particularly important in unglaciated highland areas, where their end products have been misinterpreted sometimes as evidence for glaciation.

INTRODUCTION

The main object of this contribution is to draw attention to a group of important geomorphological processes, which, locally at least, seem to have played an important part in the evolution of Tasmanian landforms and yet so far have not received proper attention. Following the nomenclature of Bryan (1946), the two most fundamental of these processes are congelifraction which involves intensive frost riving and frost shattering of rock surfaces, and congeliturbation or the mass movement of the congelifractate over very gently inclined surfaces also as a result of intense frost action. The sequence of land reduction which results from these two processes was termed cryoplanation by Bryan and is characteristic of periglacial regions where temperatures fluctuate around freezing point and rapid alternate freezing and thawing of moisture results.

Today, these processes are characteristic of subarctic and subantarctic lands, but during the glacial ages of the Pleistocene they operated much nearer to the equator and their fossil end products have now been widely recognized in North America, Europe and Northern Asia. In recent years New Zealand workers have begun to interpret landforms in terms of these processes (for example Stevens, 1957, who gives a bibliography) and Jennings (1956) has reviewed the first evidence that some landforms in south-eastern Australia may also be explained in this way. Referring to Australia, Jennings remarked that "the state of our present knowledge is well illustrated by the fact that, although about one-fifth of the area of Tasmania is thought to have been glaciated in the Pleistocene, there is scarcely a passing reference to periglacial features to be found in the published literature on that state". The present study examines the action of cryoplanation processes on Mt. Wellington near Hobart and then suggests some of the probable implications in relation to Tasmania as a whole.

Professor S. W. Carey of the University of Tasmania, Mr. J. N. Jennings of the Australian National University and Mr. K. D. Nicolls of C.S.I.R.O., Division of Soils, kindly read the manuscript and made helpful comments.

MOUNT WELLINGTON

The dolerite which caps the 4165 feet high Mt. Wellington displays strong vertical jointing and around the slopes of the mountain are great masses of dolerite boulders which have been and, in small measure, are still being derived by frost riving and frost shattering of the rock *in situ*. Some of this material lies at its angle of rest which appears to be about 25° to 30° and is probably still mobile to some extent. But much of it lies on gentler slopes, consists of residual boulders lying in a matrix of clay, and is thoroughly vegetated. It seems likely that much of this latter material is congeliturbate in origin and that a large part of the vegetated talus on the Wellington slopes dates from a time or times when congelifraction above was considerably more intense and the downward movement of talus was not restricted in the main by its normal angle of rest. On the western side of the Mt. Wellington summit this downward movement of talus at low angles has been channelled into well marked streams and these merit special mention.

Between Mt. Wellington and the Mt. Arthur ridge to the west is a broad, shallow, treeless depression, between 3200 and 3900 feet above sea level, which today is occupied by the headwaters of the North West Bay River. It is well shown in photographs presented by Martin (1940) in a study of the vegetation of Mt. Wellington. Although the depression may have originated as a stream cut valley, its present form cannot be explained in this way. Martin, who acknowledged that his geological information came from A. N. Lewis, attributed it to glacial action and described Dead Island as a nunatak. But Lewis seems to have been in two minds about the existence of glacial ice on Mt. Wellington since, although he envisaged it in some publications (Lewis, 1924, 1945), on another occasion (Lewis, 1946) he referred only to permanent snow accumulations on top of the Mt. Wellington plateau to the expressed exclusion of glacial ice. There is in fact no discernible evidence that this area has been glaciated. The broad, shallow, valley-like depressions do not head in cirques and Lewis appears to have thought in terms of a very small plateau ice-cap. He compared it (Lewis, 1924) with Ben Lomond in north-

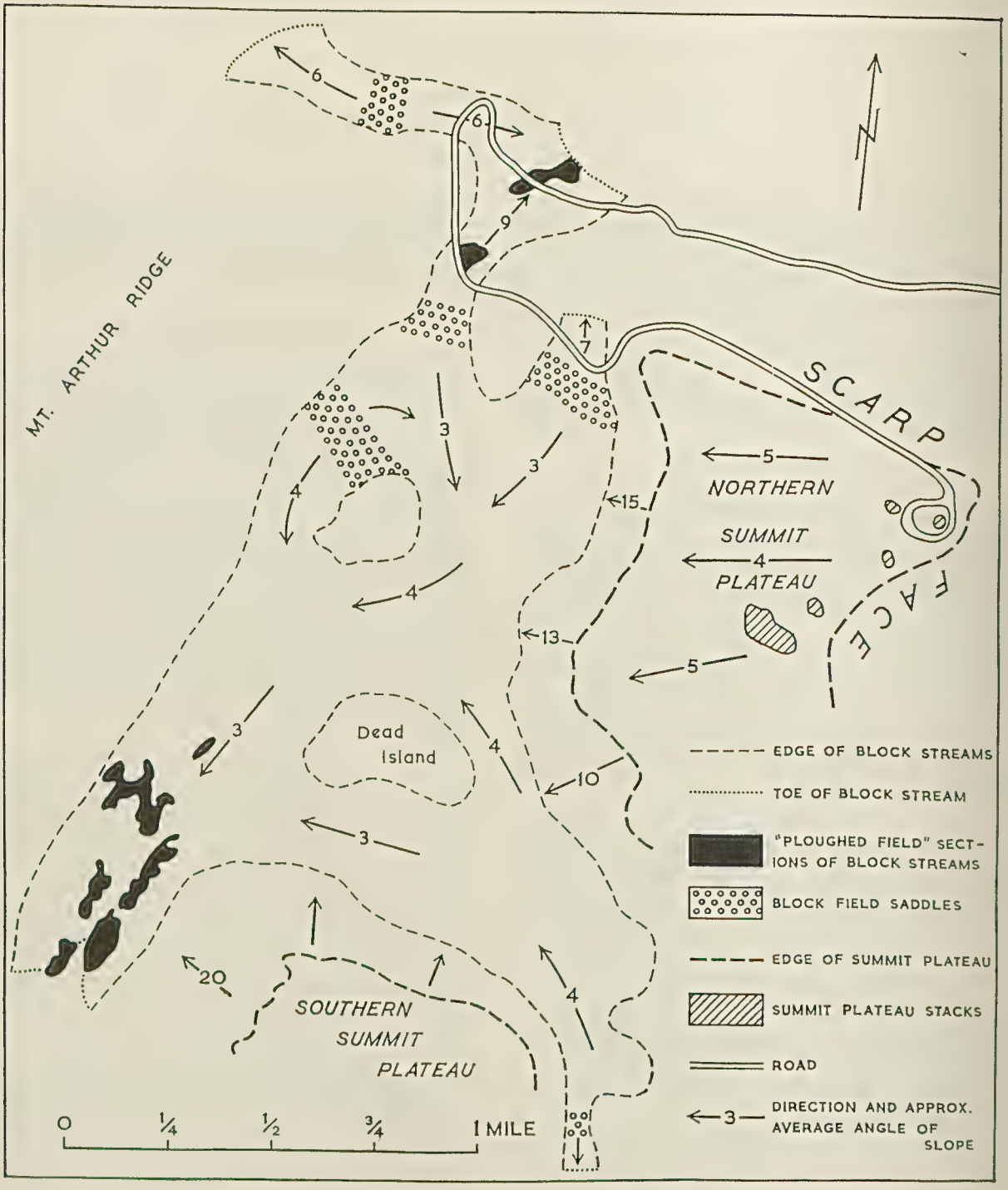

FIG. 1.—The Summit area of Mt. Wellington.

eastern Tasmania, which certainly seems to have supported such a glacier, and suggested that the two were contemporaneous. But an examination of aerial photographs suggests that the glaciated surface of Ben Lomond is freshly ice scoured and relatively unweathered, whereas the summit plateaux of Mt. Wellington are much weathered and exhibit tor-like features which could not have survived glaciation. Lewis's evidence of glaciation seems to have comprised " accumulations of rocks resembling moraines and almost certainly ice borne. At least many of them could not have rolled into their present position and it is clear that they reached their present position before the present vegetation grew up " (Lewis, 1924). Such a description would apply admirably to the congeliturbate material described earlier. Soil scientists have started to interpret the soils of Mt. Wellington in terms of periglacial processes and Loveday (1955) mapped the dominant soils above about 2000 feet as " yellow-brown soils on solifluction deposits ".

The map shows the general plan of the valley-like depressions and also the direction and degree of the slopes involved. Their surface is covered by a more or less dense mat of alpine vegetation including a variety of small shrubs. From this surface rise dolerite boulders which sometimes, as to the south of Dead Island, are clearly *in situ*, but more often, judging by their lack of joint orientation, are not. Between the latter is the normal clay matrix which is covered in part by peaty swamps. But here and there the clay matrix has been washed away to reveal the true nature of the surface of much of this depression, for, where the matrix has been removed, are masses of weathered dolerite boulders forming what locally are called " ploughed fields ". The location of these patches is shown on the map and two of them are traversed by the road ascending Mt. Wellington. Because of the removal of the matrix, some degree of subsidence has taken place so that the surface is concave and generally lower than that of the undisturbed and still vegetated, contiguous areas, but there is every reason to suppose that both vegetated and unvegetated areas are essentially similar in nature and origin. Most convincing of all in this respect are the boulder accumulations in the extreme south-west where the North West Bay River enters a comparatively narrow valley. Here is to be seen the toe of the congeliturbate standing in a steep cliff about 20 or 30 feet high and cut into by the river.

The depressions are fringed almost entirely to the west by partly vegetated dolerite talus descending at a steeper angle from the Mt. Arthur ridge. To the east and south they abut on the summit plateaux of Mt. Wellington along a line of slopes of between about 10° and 20° where the dolerite has been considerably shattered and large blocks appear to be in various stages of falling to the edge of the depression below.

This combination of circumstances, which is difficult, if not impossible, to explain by other means, can readily be interpreted in terms of the arrested cryoplanation of the Mt. Wellington plateau. The broad depressions at the head of the North West Bay River represent a system of fossil block streams which under past periglacial conditions were fed by rapid congelifraction of the dolerite on the Mt. Arthur ridge and along the edges of the Mt. Wellington summit plateau. Also at the various saddles or divides it appears that there were small block fields or Felsenmeere where the dolerite was being shattered on the surface of the depression and removed in either direction as congeliturbate.

The apparent direction and approximate average gradient of these block streams is thus indicated on the map. It will be seen that gradients vary between 3° and 9° and are therefore far outside any possible angle of slope of dolerite talus under normal conditions.

Although such block streams are well known from other parts of the world and their connection with periglacial conditions is well established (compare, for example, descriptions and photographs in Smith, 1949), the exact mechanisms by which flow takes place are not yet properly elucidated. Two such mechanisms are most widely suggested. In the first it is assumed that the frequent periodic melting of snow and ice lubricates the surface of the shattered blocks and also the finer weathered material between them. It is probable that the blocks actually moved in a matrix of finer material, in which case the existing clay matrix may be of periglacial origin or, more probably, older. The second mechanism is provided by the equally well known process of frost heave where the surface of saturated material is alternately pushed up and lowered by successive freezing and thawing. Such a heaving process would give rise to a resultant movement downhill along very slight slopes of larger material lying on the surface.

On the northern summit plateau of Mt. Wellington are several stacks of dolerite *in situ*, standing up to about 20 feet above the plateau surface and well weathered along the joint planes after the fashion of tors. Some of them support perched boulders. Whether they come fully within the genetic definition of tors as suggested by Linton (1955) is difficult to say. They undoubtedly represent residuals resulting from the removal of the weathered surrounding rock westward as congeliturbate over the plateau surface and eastward to the scarp face, but it seems likely that this was part of a single cycle of cryoplanation. Today, the northern summit plateau slopes gradually westward with slopes varying between 3° and 8° and its surface is covered with weathered dolerite boulders lying without preferred orientation of jointing in a matrix of clay and matted alpine vegetation. Along occasional snow runnels, the matrix has been removed to reveal loose, weathered boulders.

In the area occupied by the summit stacks are numerous monoliths, formed by individual joint blocks *in situ*. These are absent from the plateau surface generally, but re-appear on the convex slope immediately above the free face separating the summit plateau from the block streams. This distribution is what would be expected from a two level cryoplanation of the summit area . Along the convex slope too, are great masses of weathered dolerite boulders which can only have been derived from the plateau surface itself and have been stranded there after having moved westward as congeliturbate.

There were thus two "free faces" supplying congelifractate to the block streams from the east: one represented by the westward faces of the summit stacks and the other represented at a lower level by the steep slope between the summit plateau and the block streams themselves. Although some amount of frost shattering is still going on, block streams and congeliturbate slopes are now completely fossil.

CRYOPLANATION AND THE EVIDENCE FOR GLACIATION

Weathered block streams and other congeliturbate material may be extremely difficult to distinguish from glacial till and in the field this is often impossible, especially in Tasmania, where so many highland areas are uniformly capped with dolerite. Congeliturbate deposits will consist of unsorted materials which have moved from their point of origin and in which a large proportion of the bigger constituents have their major axes aligned parallel to the direction of movement so that when subjected to detailed examination they may simulate the fabric of till. Because they may move a long way along very gentle slopes, congeliturbate boulders may give the appearance of being glacial erratics.

The actual angle of slope over which congeliturbate material may have moved will be determined by local circumstances. In particular perhaps it will vary with the wetness or dryness of the local type of periglacial climate (Troll, 1944; Tricart, 1950) and consequently it will be difficult to make a general rule. It may be argued from the Mount Wellington example however that slopes at least as shallow as 3° carried congeliturbate in comparable Tasmanian conditions.

It follows from these considerations that, in those parts of highland Tasmania where glaciation has been inferred only from deposits which were assumed to be till, the evidence needs particularly careful appraisal. The most important case in point is probably the eastern part of the Central Plateau where there seems to be a complete lack of erosional evidence and glaciation has been assumed in the past (for example, Lewis, 1933) on the basis of superficial deposits which were not explicable in terms of normal erosion and therefore were thought to be glacial moraines. Many of these "morainic" deposits could easily be congeliturbate and the problem needs re-examination in this light.

ONE CYCLE OR TWO

Up to now it has been more or less assumed here that congeliturbate material originated as congelifractate but this was certainly not always so, for it is probable that among the congeliturbate would be material derived by chemical weathering in pre-glacial times. Linton (1955) has suggested that tors in unglaciated Britain are the result first of deep chemical weathering in warmer Pliocene climates and second of movement of much of this material downslope by periglacial solifluction during the Pleistocene. Earlier, Costin (1952) had invoked a similar two cycle theory to explain the tors of the Monaro Plateau in New South Wales. Deductive reasoning would suggest that this idea may be applicable in some Tasmanian instances. Certainly it must be assumed that a more or less deep mantle of weathered material overlay the Tasmanian highlands at the end of the Tertiary and that, under ensuing periglacial conditions, this material would be available for translation into congeliturbate. At this stage frost shattering could only take place on steep scarps and cliffs and it would require the removal of the Tertiary regolith for the full system of cryoplanation to be initiated.

To what extent these deductions may be read into the Tasmanian landscape cannot yet be assessed, but they must clearly be borne in mind.

CRYOPLANATION AND SCARP RETREAT

Along the high, dolerite capped scarps of Tasmania, frost shattering has been most active. Here there is no protecting waste mantle and the strongly jointed dolerite provides an admirable target for the freeze-thaw processes. The rate of frost shattering would have been greatly accelerated during the Pleistocene and the resulting great increase in the rate of scarp retreat would have been assisted by congeliturbate processes. At the base of the Western Tiers scarp in central Tasmania, below the zone of active scree, are fields of weathered and vegetated talus lying at angles well below the normal angle of rest of dolerite boulders. Even more significant perhaps are the "rivers" of talus which extend for more than a mile in places to the foot of the scarp (see Map square 4885 in McKellar, 1957). These appear to be true periglacial block streams for they lie at angles as low as 5° and if this is so, it is particularly interesting that they extend down to 1000 feet above sea level.

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NEW FISH RECORDS AND NOTES ON SOME UNCOMMON TASMANIAN SPECIES

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ABSTRACT

Biometrical data are given of the first adult *Centroscymnus waitei* (Thompson), *Scymnodon plunketi* (Waite) and female *Galeus boardmani* (Whitley) caught in Australian waters.

The following fish species are also new records for Tasmania:—*Parascyllium ferrugineus* McCulloch, *Halaelurus vincenti* (Zeitz), *Beryx decadactylus* Cuvier, *Neocyttus rhomboidalis* var. *gibbosus* McCulloch, *Anthias pulchellus* Waite and *Ophioclinus gracilis* Waite.

New place localities are given for:—*Diastobranchus danae* (Bruun), *Muraenichthys breviceps* Günther, *Paratrachichthys trailli* (Hutton), *Brama raii* (Bloch), *Arripis georgianus* (Valenciennes), *Gasterochisma melampus* Richardson, *Rexea solandri* (Cuvier), *Bovichthys angustifrons* Regan, *Petraites johnstoni* (Saville Kent), *Arenogobius bifrenatus* (Kner) and *Pataecus maculatus* Günther.

INTRODUCTION

The purpose of this paper is to record additions to the fish fauna and list extensions of localities for some uncommon fish. Biometrical data have been presented for some species.

During the past seven years commercial fishing operations have extended into waters beyond the continental shelf and as a result, fish previously unknown from Australia, have been caught.

Strange fish are being made available for identification by fishermen so much more readily now that they are able to hold specimens for long periods under refrigeration. Previously they had experienced difficulty in preserving such fish. It has been possible to make these additions to the fish fauna list only through the interest of fishermen and the use of freezer storage.

NEW AUSTRALIAN AND TASMANIAN RECORDS

Family SQUALIDAE

Centroscymnus waitei (Thompson, 1930). Waite's deep-sea dogfish.

This species was known previously only from the holotype, a juvenile male 318 mm. total length, taken on a long line in deep water off Kaikoura, New Zealand, August, 1928 (Garrick, 1955).

Both Tasmanian specimens listed here were caught on long lines on the continental shelf slope in 400-500 f. off the east coast of Tasmania.

Scymnodon plunketi (Waite, 1910). Lord Plunket's Shark.

One male, 1310 mm. and one female, 1370 mm., both mature, were taken under similar conditions to the previous species.

On the basis of the capture of these fish, Munro (1956) listed these species, Nos. 81 and 82 in his Handbook of Australian Fishes. Cowper and Downie (1957) referred to the catching of more specimens of these species.

Measurements (mm.) of both *C. waitei* and the female *S. plunketi* are as follows:—

	Centroscymnus waitei		*Scymnodon plunketi*	
	female	female	female	male
Snout tip to outer nostril	18	9	33	....
Snout tip to eye	46	29	60	....
Snout tip to spiracle	101	71	150	....
Snout tip to 1st gill	134	99	227	....
Snout tip to 2nd gill	144	104	236	....
Snout tip to 3rd gill	149	109	245	....
Snout tip to 4th gill	159	113	250	....
Snout tip to 5th gill	167	116	—	....
Snout tip to base of pectoral fin	180	116	274	....
Snout tip to base of 1st dorsal fin	347	189	270	....
Snout tip to base of pelvic fin	643	331	765	....
Snout tip to base of 2nd dorsal	726	360	835	....
Snout tip to base of lower caudal fin	830	445	1,023	....
Snout tip to base of upper caudal fin	875	455	1,070	....
Total length	1,070	588	1,370	1,310
Trunk at pectoral origin breadth	—	90	200	....
height	—	50	175	....
Colour	Dark-brown	Light-grey	Light grey-brown	....
Locality	Cont. slope Maria Is.	15m. N.E. Wineglass Bay	Cont. slope Maria Is.	400 f. Maria Is.
Date	10. v. 51	9. vii. 52	10. v. 51	16. vi. 53

C. waitei. 1st dorsal origin behind posterior insertion of pectoral base. Distance between origins of 1st dorsal and pelvic fins approximately twice total length of dorsal fin. Origin of second dorsal fin behind pelvic origin. Distance between inner corners of nostrils 1/22 length of body. Horizontal diameter of eye 2¾ vertical diameter. 1st dorsal origin approximately half way between 2nd dorsal and snout. 2nd dorsal origin 2/3 distance from snout to distal margin of caudal. Pectoral 1/5, and pelvic 3/5 distance from snout to distal margin of caudal. Placoid scales: The hollowed out upper surface of the blade, plus the lack of ridges, denticulations and other sculpture are very characteristic of the genus *Centroscymnus* (Garrick, 1955). Female 1070 mm.—the two uteri each contained 6-12 recently ovulated eggs; liver lobes extended full length of body cavity, the left one was the longer.

S. plunketi.—1st dorsal origin slightly in front of pectoral origin. Thirteen embryos, five males and eight females averaging about 12 cm. were removed from the uteri. Two yolk sacs measured 45 x 50 mm. and 55 x 40 mm.

NEW TASMANIAN RECORDS

Family ORECTOLOBIDAE

Parascyllium ferrugineum McCulloch, 1911. Rusty Catshark.

Both catsharks were caught during March, 1952, in graball nets off the Forestier Peninsula, East Coast.

Family SCYLIORHINIDAE

Halaelurus vincenti (Zeitz, 1908). Gulf Catshark.

Previously this species of catshark was only known from South Australia and Victoria, but in May, 1951, a specimen was caught in a graball net in George Bay, near St. Helens. Biometrical data (mm) have been compared with those of two *Halaelurus analis* (Ogilby). For convenience similar data have been listed in the same table for the two specimens of *P. ferrugineum* Waite.

	P. ferrugineum		*H. vincenti*	*H. analis*	
Total length	825	784	462	574	614
Snout tip to 1st dorsal	420	390	215	260	277
Snout tip to 2nd dorsal	580	540	305	380	403
Snout tip to origin of pectoral	130	....	78	96	97
Snout tip to origin of ventral	315	...	...	208	224
Snout tip to origin base anal	520	510	266	320	338
Snout tip to base lower caudal	665	630	354	445	466
Clasper length (to outer edge of membrane)	...	..	67	43	46
Snout to anterior edge of pectoral	130	115	78	96	...
Snout to anterior edge posterior insertion of pectoral	150	144	98	119	120
Snout to anterior edge of ventral	315	290	166	208	...
Snout to anterior edge posterior insertion of ventral	365	338	202	•254	255
Sex	Mature female	Mature female (ova 30 mm.)	Mature male	? male	Mature male
Length of gill opening 1	11	9	8	13	13
Length of gill opening 2	13	10	7	12	12
Length of gill opening 3	12	11	6	11	11
Length of gill opening 4	10	10	4	9	9
Length of gill opening 5	28	27	3	5	4
General colour	Light grey-brown with grey bands	Grey background, very dark brown band	Very dark-brown	Light grey brown	Light grey-brown
Spots	Very dark-brown	Very dark-brown	Creamy white	Dark-brown	....
Size of spots (diam. mm.)	5-8	5-8	....	2-5	2-5

Galeus boardmani (Whitley, 1928). Sawtail Shark.

This species was previously known only from males and the female caught on 2. vii. 52 in 300 f. off Maria Island is the 1st record of its sex of this species. Details of measurements (mm.) are as follows:—

Snout tip to anterior edge of eye	30
Snout tip to posterior edge of eye	48
Snout tip to spiracle edge of eye	54
Snout tip to 1st gill slit	68
Snout tip to 5th gill silt	87
Snout tip to base of pectoral	85
Origin of vent	200
Base of 1st dorsal	285
Base of 2nd dorsal	330
Base lower caudal fin	390
Total length	503
Weight	¾ lb.

There were 14 transverse bands of dark colour on the dorsal surface, the anterior band extended between the eyes.

There is a latex cast in the National Museum, Melbourne, the carcase has been lost.

Family BERYCIDAE

Beryx decadactylus Cuvier, 1829.

This fish was caught on a long line set on 17.1.52 in 300 f. off Maria Island. Previously its southern limits were over 100 f. in north-eastern Bass Strait.

Family ZEIDAE

Neocyttus rhomboidalis var. *gibbosus* McCulloch, 1914. Spiky Dory.

This fish was caught during July, 1951, on a long line in 100 f. off Maria Island. The first record of this species was made by the F.I.S. "Endeavour" during the 1912-13 operations in the Great Australian Bight. There are only three anal spines present in this specimen. Dimensions (mm.):—

Length of head to operculum	123
Depth of body at origin of 1st dorsal	192
Length to caudal fork (LCF)	340

Family OPHIOCLINIDAE

Ophioclinus gracilis Waite, 1906.

This blenny was present in the gut contents of juvenile school sharks caught on 26.viii.50 in George Bay (St. Helens). It is a common food fish for the small sharks in this estuary.

Family ANTHIIDAE

Anthias pulchellus Waite, 1899. Orange Perch

A single specimen was trapped in a net-covered craypot attached to a long line set on 21.x.50 in 200 f. west of King Island.

NEW PLACE LOCALITIES

Family SYNAPHOBRANCHIDAE

Diastobranchus danae (Bruun, 1937). Basket-work Eel.

The adults of this eel were first caught on a long line set on 10.vii.51 in 100 f. off Maria Island. The writer sent a gravid female, 1225 mm. to Sydney for identification and the species was recorded by Whitley (1952). Since then more eels have been caught on a long line on 8.v.53 in 600 f. west of King Island.

Biometrical details (mm.) are as follows:—

	Maria Island 100 f.		King Island 600 f.		
	1	2	1	2	3
Snout tip to anterior edge of eye	43	55	40	42	33
Snout tip to posterior edge of eye	65	75	62	61	48
Snout tip to origin pectoral	147	170	134	130	102
Snout tip to vent	252	290	235	205	175
Snout tip to origin dorsal	335	430	345	326	233
Maximum depth (end of pectoral)	73	83	75	75	...
Snout to nostril	10	17	14	13	11
Total length	1,085	1,225	1,005+	985	777
Sex	....	female (mature)	female (mature)	male	?
Weight (lb.)	2¾	4¼	3⅜	3 1/16	1¼

Family ECHELIDAE

Muraenichthys breviceps Günther, 1876. Short-headed worm eel.

This eel occurs along the silty foreshore between Middleton and Gordon, D'Entrecasteaux Channel, where it is recognized by the reddish-brown colour it reflects from underwater lights. A specimen, T.L. 494 mm. was speared in this area on 22.x.57 by Mr. T. Wolfe.

Family TRACHICHTHYIDAE

Paratrachichthys trailli (Hutton, 1876). Sawbelly or Sandpaper fish.

This species is generally considered as a deep-water inhabitant and usually is caught by trawling. On 28.iv.53, several were caught in a graball at Freestone Point, Spring Bay. Two specimens brought in for identification measured L.C.F. 200 mm. and 185 mm. Another specimen L.C.F. 140 mm. was caught on 15.i.57 in a graball at Pilot Bay Beach, Cape Sorell.

Family BRAMIDAE

Brama raii (Bloch, 1791). Ray's Bream or Pomfret.

As *Lepidotus squamosus* (Hutton, 1875) the first Tasmanian occurrences of Ray's bream were reported by Scott (1955) from Temma (July, 1953) and later the same year on a long line set on 20.x.53 in 250 f. E.S.E., Tasman Peninsula. A short time after this second report three more were caught, one at Port Davey (1954) and two in Storm Bay (2 and 12.iii.54), and another at Coles Bay (April, 1955).

With the exception of the Coles Bay specimen which was caught by hand in shallow water, the others were hooked on tow lines. Measurements (mm.) of both Storm Bay specimens are as follows:—

	2.iii.54	12.iii.54
Snout to caudal fork (L.C.F.)	273	284
Snout to operculum	69	67
Depth of body at 1st dorsal origin	112	116

The classification of Ray's bream is most contentious and because both Storm Bay specimens (the only ones available for study) had 57-59 transverse rows of scales (anterior to pectoral fin), a lateral line and scales with finely toothed edges these specimens have been reported under the above more widely known, but not necessarily correct, name.

Family ARRIPIDAE

Arripis georgianus (Valenciennes, 1831). Tommy Rough.

From specimens caught on 18.iii.37 at George Town, Scott (1939) was able to add this species to the Tasmanian fish fauna list. During August, 1952, a number of these fish were caught in a seine net at Port Sorell which is now a new place record for this species.

Total length	710
Length to caudal fork	632
Snout to anterior edge of eye	57
Snout to posterior edge of eye	72
Snout to operculum	141
Snout to anterior insertion of pectoral	157
Snout to anterior insertion of pelvic	150
Snout to anterior insertion of anal	400
Snout to 1st dorsal origin	68
Snout to 2nd dorsal origin	370
Length of pectoral fin	90
Length of pelvic fin	140 (damaged)
Depth of body	....
Depth of body { origin of 1st dorsal	160
Depth of body { origin of 2nd dorsal	150

Family GEMPYLIDAE

Rexea solandri (Cuvier, 1831). King Barracouta.

Formerly plentiful these fish are now taken mostly on long lines in deep water. On 12.i.56, a damaged living specimen was washed ashore on the Pilot Bay Beach, Cape Sorell.

Family BOVICTIDAE

Bovichthys angustifrons Regan, 1913.

This gurnard-like fish is known only from two specimens, one in the British Museum from Tasmania and the other in the Chatham Museum from an unknown locality. During April, 1950, a third fish was caught by Mr. S. E. Dale on a long line in 30 f. off South West Cape. It has been preserved in the collection of the C.S.I.R.O. Division of Fisheries and Oceanography, Cronulla, N.S.W.

Family CLINIDAE

Petraites johnstoni (Saville Kent, 1886). Weed fish.

Formerly, this fish was known only from the Tamar River but many specimens mostly between 200-300 mm. total length have been received for identification from south-east Tasmania. As the common name indicates it is found close inshore in seagrass and seaweed beds.

Family SCOMBRIDAE

Gasterochisma melampus Richardson, 1845. Butterfly Mackerel.

This rare oceanic species was first recorded in 1845 from New Zealand. It has been reported three times previously from Tasmanian waters (i) Bass Strait (1867), (ii) mouth of Derwent Estuary (T.L. 39 ins.), (iii) Storm Bay (1944). On 18.vi.50 the fourth record, T.L. 710 mm., L.C.F. 632 mm., was caught on a tow line off South East Cape and on 27.v.53) another fish L.C.F. 560 mm. was landed on a tow line in Spring Bay.

While spearing flounders on the night of 30.v.54 in 4 feet of water inside the entrance of Pittwater, Mr. K. Crome, Hobart, saw a school of 8-10 fish which used their large pectoral fins for brakes as they approached his underwater light. He speared two and submitted them for identification. They were butterfly mackerel and biometrical observations (mm.) of these and the South East Cape specimen are as follows:—

South East Cape	Pittwater 1	Pittwater 2
710	288	251
632	253	228
57	19	15
72	28	24
141	56	49
157	58	51
150	57	50
400	150	133
68	61	56
370	142	123
90	28	22
140 (damaged)	88	80
....	....	....
160	54	48
150	56	47

Family GOBIIDAE

Arenigobius bifrenatus (Kner, 1865). Bridled goby.

This viviparous goby, like *Ophioclinus gracilis* Waite mentioned earlier, forms a part of the diet of juvenile school sharks in George Bay (St. Helens). Specimens were collected in 1950 and identified by Mr. I. S. R. Munro, C.S.I.R.O. Division of Fisheries and Oceanography. Reference to their occurrence in George Bay was made earlier (Olsen, 1954). Whitley (1954) listed it as a new record for Tasmania from a specimen caught in West Arm, Tamar River.

Family PATAECIDAE

Pataecus maculatus Günther, 1861. Warty Prow Fish.

The presence of this fish in Tasmanian waters was not confirmed until 1936 (Scott, 1936). Specimen No. 890 in the Queen Victoria Museum is from Northern Tasmania, probably Tamar Heads. A second specimen 195 mm. was caught during April, 1954, in a graball net at Port Sorell.

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CHROMOSOME NUMBERS IN TASMANIAN GOODENIACEAE AND BRUNONIACEAE

By

W. D. JACKSON

Department of Botany, University of Tasmania

(WITH 1 TEXT FIGURE)

ABSTRACT

Species of *Goodenia, Velleia, Selliera* and *Scaevola* have a basic chromosome number of 8, whilst *Dampiera* and *Brunonia* show a basic number of 9. With the exception of *Selliera radicans* which has diploid and hexaploid races, all others are diploid.

INTRODUCTION

Thirteen members of the Goodeniaceae and the monotypic *Brunonia australis* have been recorded from Tasmania. None are endemic. Four species are rare or are doubtful records. Four are restricted in distribution, while the other five are common species with wide distributions. With the possible exception of the sub-herbaceous Goodenias, the Tasmanian members offer few taxonomic difficulties. The principle interest lies in the relationships between genera and the position of *Brunonia* which has in the past been grouped with the Goodeniaceae.

At present there is no published account of chromosome numbers in this distinctive Australian group. However, P. Martin (University of Adelaide) is at present working on the Australian members.

MATERIALS AND METHODS

Only Tasmanian specimens were studied. Where possible material was obtained from different environments and from a wide range in the Tasmanian distribution. Morphological variants common in *Goodenia humilis, G. elongata* and *G. lanata* were investigated.

Meiosis in pollen mother cells was studied using aceto-orcein and aceto-lacmoid smear methods (Darlington and La Cour, 1947). Root tips were used for the study of mitosis, both untreated and with treatments of aqueous solutions of paradichlorobenzene (Meyer, 1945) before fixation in acetic-alcohol. Acetic stains were used for most of the investigation. Feulgen staining was tried, but no satisfactory stain intensity was obtained.

OBSERVATIONS AND DISCUSSION

A summary of the counts determined and the origin of the material is given in Table I. Drawings of representative plates are provided in the text figure.

In the Goodeniaceae the chromosome complement is surprisingly uniform in both number and morphology. Apart from *Dampiera stricta* with $2n = 18$, the Tasmanian members investigated all have the diploid number $2n = 16$, except in *Selliera radicans* where a hexaploid $2n = 48$ was found in addition to the diploid form. There do not appear to be any significant morphological differences between these two chromosome races, which were found in the same locality. The chromosome number of *Brunonia australis* is $2n = 18$. Meiosis was normal in all specimens and pollen fertility, as measured by stainable pollen, was high. There is no evidence of apomixis in the members studied.

The chromosomes are fairly small. In mitotic metaphase the chromosomes range from 2·5-4 μ in length. Mitotic plates are small and compact. Narrow meiotic spindles are a feature of the Goodeniaceae, with cross sectional areas 1/20th that of the pollen mother cell section. This feature while common to all species of the Goodeniaceae studied is not found in *Brunonia australis*.

As mentioned above, the chromosome complement in the Goodeniaceae is markedly uniform. Although *Dampiera stricta* has a haploid complement of nine, studies of chromosome morphology indicate that eight of these are indistinguishable from the genome in other genera. All the chromosomes are metacentric, with four shorter chromosomes with a 5/4 arm ratio. One of the four long members has a 1/1 arm ratio while the ratio in the other three is approximately 3/2. The long arm of one of these has a prominent trabant. In *Dampiera stricta* the complement appears to be identical apart from the addition of another short chromosome with a 1/1 arm ratio. Martin (unpub.) has found polyploid series based on $x = 9$ in mainland members of *Leschenaultia* and *Dampiera*. *Brunonia australis* appears to possess eight members similar to that in the eight membered Goodeniaceae. There the additional member to the haploid set is a long chromosome with a 5/4 arm ratio and a heterochromatic segment near the distal end of the short arm.

Practically all chiasmata are terminal or nearly so. In *Brunonia* the distal localization of chiasmata is most pronounced. *Brunonia australis* also differs from the members of the Goodeniaceae studied in having a larger cell size and a relatively larger spindle. With these exceptions the group appears to be homogeneous cytologically, based on $x = 8$ and $x = 9$, with some apparent uniformity in chromosome morphology.

I wish to acknowledge the kind assistance of Mr. T. E. Burns in collecting material in Northern Tasmania.

TABLE I

Chromosome numbers of Tasmanian Goodeniaceae and Brunoniaceae.

Species	Collecting locality and altitude		Remarks	Chromosome number	
				2n	n
GOODENIACEAE					
Velleia, Sm.					
V. montana, Hook. f.	King William Saddle	2,800	robust lvs. 10 cm.	16	8
	Interlaken	2,600	reduced lvs. 4-5 cm.	16	8
V. paradoxa, R.Br.	Springfield, Glenorchy	200	robust lvs. 14 cm. glabrous	16	8
	Georgetown	100	lvs. 7 cm. hairy entire ±	16	8
Goodenia, Sm.					
G. ovata, Sm.	Tolosa St., Glenorchy	200	typical	16	8
	St. Marys	800	typical	16	....
G. amplexans, F.v.M.	Not collected	....			
G. barbata, R.Br.	Not collected	....			
G. geniculata, R.Br.	Not collected	....			
G. lanata, R.Br.	Mt. Nelson	300	typical	16	8
	Murdunna	50	lvs. 3 cm. x 2·5 cm.	16	8
	Low Head	50	lvs. 4 cm. x 1·5 cm.	16	....
G. elongata, Labill.	St. Helens	50	hairy reduced	16	8
	Low Head	100	± glabrous robust	16	8
G. humilis, R.Br.	Low Head	20	typical lvs. 3 cm.	16	8
	Low Head	20	robust lvs. 5 cm. x 0·5 cm.	16	8
Selliera, Cav.					
S. radicans, Cav.	Glenorchy	....	typical	16	8
	Glenorchy	....	typical	48	24
Scaevola, Linn.					
S. hookeri, F.v.M.	Mt. Wellington	4,000	reduced	16	8
	Collins Cap	1,900	robust	16	....
Dampiera, R.Br.					
D. stricta, R.Br.	Bicheno	50	typical	18	9
BRUNONIACEAE					
Brunonia, Sm.					
B. australis, Sm.	Queechy Hill, Laun.	50	typical	18	9

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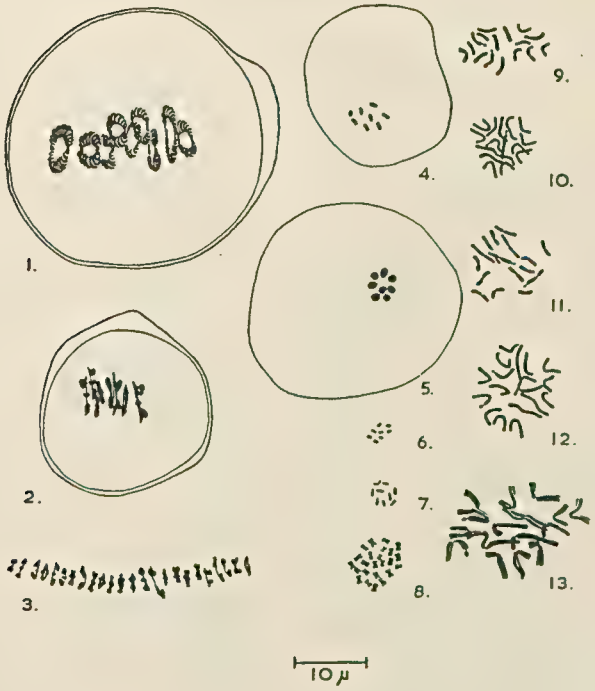
FIGURE 1



Side View

Metaphase I

1. *Brunonia australis* n = 9
2. *Goodenia ovata* n = 8
3. *Selliera radicans* n = 24

Polar View

Metaphase II

4. *Goodenia humilis* n = 8
5. *Velleia montana* n = 8
6. *Goodenia ovata* n = 8
7. *Dampiera stricta* n = 9
8. *Selliera radicans* n = 24.

Polar View

Mitotic Metaphase

9. *Velleia montana* 2n = 16
10. *Goodenia lanata* 2n = 16
11. *Goodenia elongata* 2n = 16
12. *Dampiera stricta* 2n = 18
13. *Scaevola hookeri* 2n = 16

PAPERS AND PROCEEDINGS OF THE ROYAL SOCIETY OF TASMANIA, VOLUME 92

THE FISHER ISLAND FIELD STATION—WITH AN ACCOUNT OF ITS PRINCIPAL FAUNA AND FLORA

By

E. R. GUILER, D. L. SERVENTY AND J. H. WILLIS

(WITH 2 PLATES AND 9 TEXT FIGURES)

I. GENERAL DESCRIPTION OF FISHER ISLAND AND ITS MUTTON-BIRD ROOKERIES*

INTRODUCTION

Fisher Island (lat. 40° 10′ S., long. 148° 16′ E.) is among the smallest of the archipelago of islands comprising the Furneaux Group in eastern Bass Strait. It lies off the southern shoreline of the major island in the group, Flinders Island, in Adelaide Bay, a portion of Franklin Sound which separates Flinders Island from Cape Barren Island (fig. 1). Its convenient location to Lady Barron (the main port of Flinders Island, about 220 yards distant), its proximity to important commercial mutton-birding islands and the presence of a small, easily handled nesting colony of mutton-birds (*Puffinus tenuirostris* (Temminck)), made it the obvious choice for a field station when the Commonwealth Scientific and Industrial Research Organization and the Fauna Board of Tasmania began their mutton-bird investigations in 1947.

The island was too small to be specifically noticed in the Admiralty surveys. To the local inhabitants it has been known as Little Island, but in 1941, at the suggestion of Colonel J. E. C. Lord, it was officially named Fisher Island by the Lands Department in honour of Police Sergeant George A. Fisher. This officer, when he was stationed at Flinders Island between 1926 and 1934, undertook investigations on the homing of the mutton-birds on it by means of marking experiments.

The island was declared a fauna sanctuary in 1928, but prior to that date had been constantly raided during the mutton-bird season for eggs and fledglings. For a time a Flinders Island landholder pastured goats on it.

After the island was selected as the site for a field station to investigate the biology of *Puffinus tenuirostris* a single-roomed hut was constructed on it in 1948. This accommodated four persons. An extension in 1956 provided for two additional persons, and the facilities allow field parties comprised of mixed sexes being based on the island. Water is supplied by the roof catchment.

PHYSICAL DESCRIPTION

Fisher Island has an area above high-water mark of 2·1 acres or 10,100 square yards. The additional area uncovered at extreme low tide is approximately 0·75 acres. The shoreline measures about 530 yards and the greatest length, from North Point to South Point, is 150 yards. Its elevation is about 19 feet above spring high-water mark.

Like the other islands in the Furneaux Group, Fisher Island is part of the basement Devonian granite which forms the hills and mountain ridges in the archipelago. On Flinders Island the low-lying plains are covered by Tertiary alluvium and sands, with calcareous deposits in restricted areas. Limited Siluro-Devonian quartzites and slates also occur, and in the northern part of Adelaide Bay, at Petrifaction Bay, are exposures of Tertiary vesicular basalts. None of these formations, however, enter into the structure of Fisher Island, which consists solely of a flattened granite dome, with a limited soil covering which reaches its maximum depth of two feet in only a few places. There is no trace of the post-Tertiary sandy limestone which forms a capping, or limited crust, on some of the other smaller islands, such as Green Island (off Whitemark), Kangaroo Island, Big Woody Island and Tin Kettle Island. This limestone weathers into a richer residual soil than the sandy soils of the granite areas, and hence such islands were soon exploited for pastoral purposes when Flinders Island was settled. This led, in many cases, to the drastic alteration of the environment, detrimental to any mutton-bird colonies that might have been on them. The absence of limestone on such islands as Great and Little Dog, and Little Green Island, and Babel Island, saved them from such severe habitat alteration and they survive as extensive mutton-bird rookeries. A soil survey of the main island of Flinders has been made by Dimmock (1957) but the surrounding islets have not been reported on.

Fisher Island has a fairly level appearance when viewed from seaward, the highest elevation being to the south-west of the buildings. In the south a slight gully has been eroded along the jointing planes in the granite (Snake Gully). On the eastern shore a wave-cut platform, awash at high spring tides, has been eroded. At Potts Point it has a width of 40 feet, and is backed by a low cliff up to nine feet high. Exfoliation is taking place along the margins near North Point and north-west of the hut where, in combination with jointing, the feature known as the Fingers has been produced. Some of the loose blocks here have been displaced seawards. The margin between tide marks is

* By D. L. Serventy, C.S.I.R.O., Wildlife Survey Section.

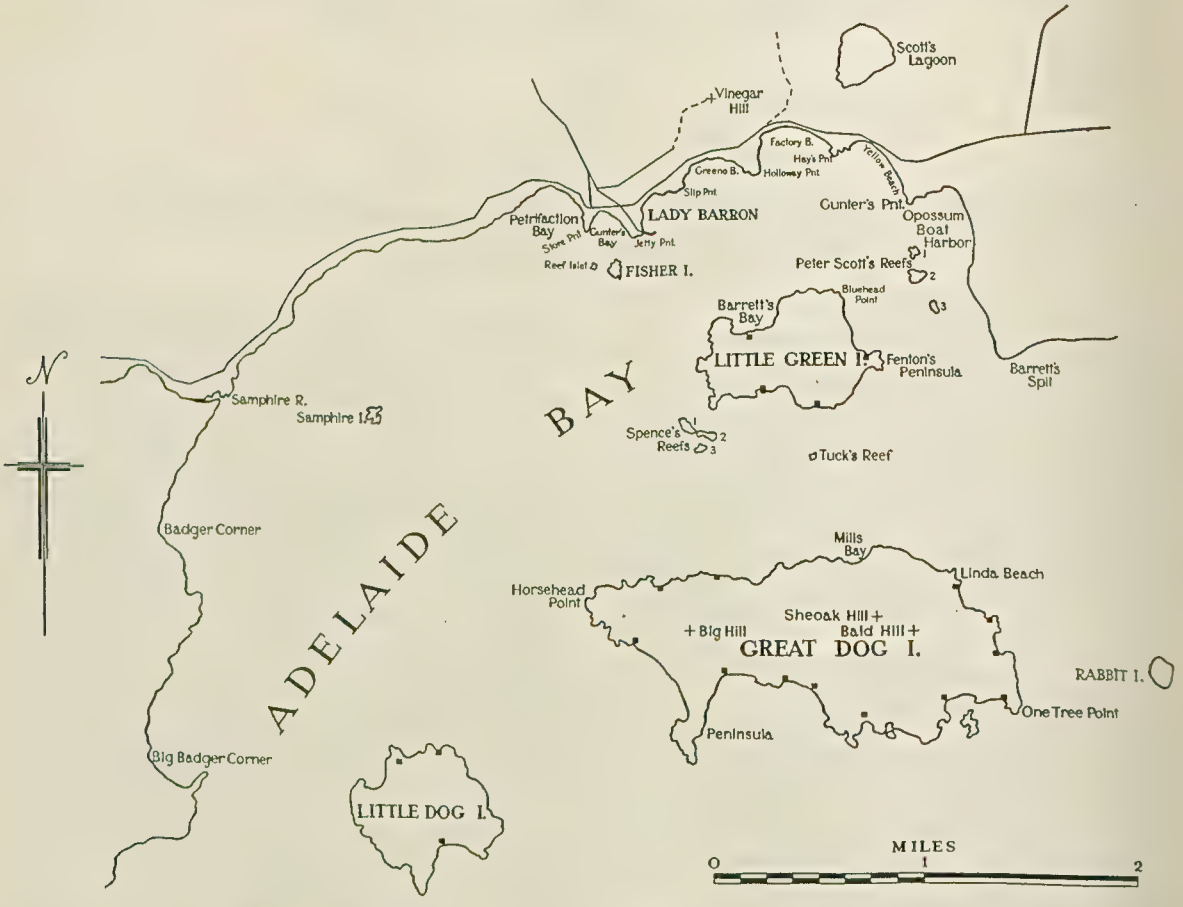


FIG. 1.—Portion of Adelaide Bay based on aerial surveys by the Tasmanian Lands Department.

littered with water-worn granite boulders, particularly along the west and south-west shores. North-east Boat Harbour is the single sandy beach on the island but is only exposed at low water.

THE MARINE ENVIRONMENT

The *Australia Pilot* describes Franklin Sound as " much encumbered by islands and shallow banks, between which there is a somewhat tortuous and, in places, narrow channel available only for vessels with local knowledge ". The Sound is sheltered from the oceanic swell and its north-eastern extension, Adelaide Bay, in which Fisher Island lies, is virtually land-blocked.

(a) *Tides*

The range of ordinary spring tides at Fisher Island is just under six feet and of neap tides about four feet. " King " spring tides may range almost two feet more than ordinary spring tides. High water at Full and Change is at 10.15 hours, which means that low-water spring tides occur, during the day, about 5 o'clock in the afternoon. The tidal range is about the same throughout Franklin Sound, as far west as Long Island, but it is greater in the open sea outside the Sound. The range at Goose Island is about nine feet at average tides.

Around Fisher Island the flood tide flows, in general, from east to west, and at ebb from west to east. However for about 1½ to 2 hours before high water the direction of the flood tide is reversed and it flows from the westward. The velocity of the tidal current in the general area is given by the *Australia Pilot* as from 2 to 2½ knots. Around the shores of Fisher Island, however, the rate is faster and would be about three knots.

(b) *Sea Temperatures*

Sea water surface temperatures have not been taken in Franklin Sound but the C.S.I.R.O. Division of Fisheries and Oceanography has records from three sampling stations in neighbouring waters (Rochford, 1951-57). These are: off Babel Island (lat. 39° 54′ S., long. 148° 30′ E.), off St. Helens (lat. 41° 18′, long. 148° 30′), and off Low Head (lat. 40° 55′, long. 146° 46′).

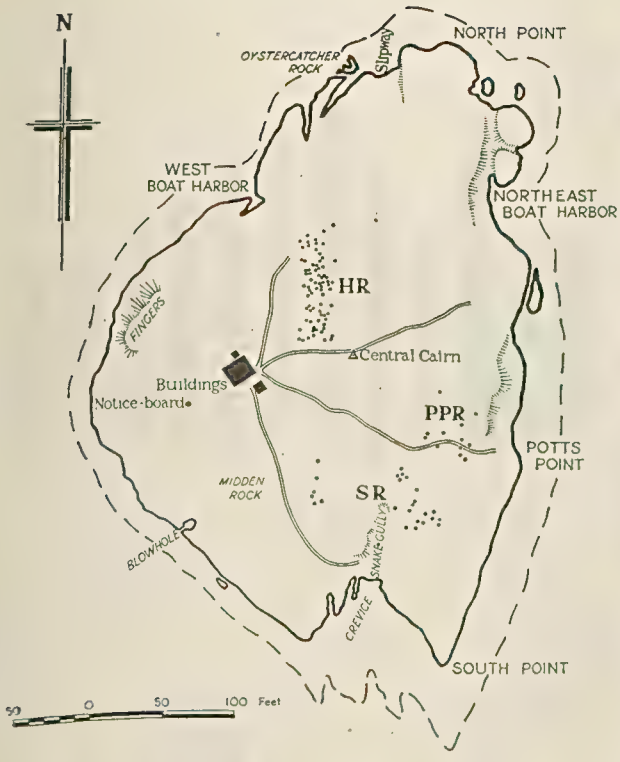


FIG. 2.—Map of Fisher Island after a survey by G. M. Storr, 1952. The occupied mutton-bird burrows in the season 1956-57 are represented by dots. HR = Home Rookery; SR = South Rookery; PPR = Potts Point Rookery.

Off Babel Island surface temperatures vary from 16-18°C. in the summer months (highest recording 18·8° on January 20, 1941) to just under 13° in the winter months (lowest recording 12·7° on August 25, 1940), but there is considerable fluctuation. The temperature becomes higher off-shore, owing to the influence of the warm, southward-flowing East Australian Current. Thus about 30 miles east of Babel Island the surface temperatures in the summer are between 18° and 19° (the highest recording being 19·2° on February 21, 1940). In the winter they drop to just over 13° (lowest recording 13° on August 25, 1940).

At St. Helens the temperatures average slightly lower. The inshore surface values vary from 15° to 18° in the summer and from about 11° to just under 13° in the winter (lowest recording 10·6° on September 24, 1946).

At Low Head the winter temperatures fall slightly below those of Babel Island, and the range lies between about 11° and 12°.

These figures accord broadly with other temperature data reviewed by Garner (1954). A detailed review of the hydrological characteristics of the Tasman Sea region including the waters around the Furneaux Group, is given by Rochford (1957).

CLIMATE

(a) *Rainfall*

A considerable proportion of the rainfall in this area is orographical. In Bass Strait away from land the annual rainfall is only about 20 inches. (Goose Island, the most remote islet in the Furneaux Group, has averaged 22 inches over a 38-year period). The coasts of the larger islands receive 27-30 inches. Inland there is further increase in precipitation according to elevation; the highest rainfall is probably in the Strzelecki Range, which attains an altitude of 2550 feet.

The nearest rainfall-recording station to Fisher Island is Lady Barron, where records have been kept for 15 years. The annual average is 30·45 inches at Lady Barron, 29·42 inches at Pat's River (for 10 years), and 28·48 inches at Whitemark (for 32 years). The main mutton-birding islands in Franklin Sound would all receive about 30 inches.

The monthly distribution of rainfall at Lady Barron is graphed in fig. 3. It will be seen that the rainfall is predominantly of the winter type, but with generous falls in the remaining months. It is the rainfall in these months, mainly from November to March, that affects the welfare of the mutton-bird rookeries.

On occasions when the late spring, summer and autumn rainfall is abnormally high the mutton-bird rookeries, particularly in the low-lying areas, may suffer severely from flooding. In recent years two seasons have been commercially disastrous because of such rains. In November, 1949, rainfall, totalling 5·52 inches at Lady Barron and 7·26 inches at Pat's River (13 miles N.W. of Fisher Island), devastated the low-lying rookeries at the crucial egg-laying period. The Fauna Board was compelled to cancel commercial mutton-birding at Great and Little Dog and Little Green Islands in the following March-April period.

The greater falls in the summer of 1955-56 also led to a curtailment of the commercial season. The daily falls from December to March during this season are graphed in fig. 4, which demonstrates how repeated heavy precipitation at frequent intervals from late December, culminating in sustained falls in February, deluged the rookeries. The total rainfall for the months December to March, inclusive, was 17·91 inches (for Pat's River, the Lady Barron station having been temporarily discontinued). This is 10½ inches more than the Pat's River average for the period.

The Bureau of Meteorology has analysed the rainfall records of nine selected stations in the Furneaux Group by means of cumulated frequency curves and the percentage chances of receiving specified monthly totals for each month have been calculated. These stations were chosen out of the 12 recording stations on the islands because they have been operating for relatively long periods. The chances of a precipitation of five inches or more at Pat's River at each of the crucial months of the mutton-bird season are as follows:—

November: 6 times in 100 years.
December: twice in 100 years.
January and February: 6 times in 100 years.
March: 9 times in 100 years.

The chance of receiving 10 inches or more of rain in the period December to February, inclusive, has been calculated as 3 times in 100 years, but falls of six inches can be expected in three summers out of 10. Thus the season 1955-56 must be accounted as most extraordinary; the exceptionally heavy summer rains being due to the passage of repeated sub-tropical pressure systems.

On the other hand, relatively dry weather during this period tends to enhance breeding success by the mutton-birds. Fortunately there is a far greater expectancy of such weather than abnormally wet weather. Thus, Whitemark has a 95 per cent chance of receiving only two inches of rain in the period December-February, an 86 per cent chance of receiving three inches, and 70 per cent chance of receiving four inches.

The Goose Island figures are, from the point of view of the mutton-bird environment, more favourable than the Franklin Sound islands. Hence it may be assumed that Chappell Island, and to a lesser extent Babel Island also, will fare better in heavy rainfall years than the Sound islands.

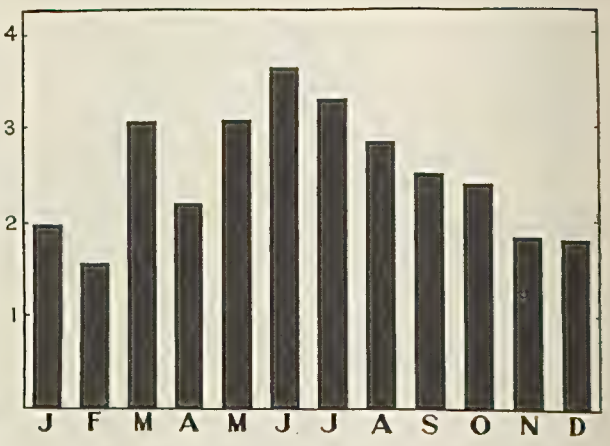


FIG. 3.—Mean monthly rainfall in inches, Lady Barron.

(b) *Temperature*

There are no temperature recording stations in the Flinders Island region, and the data in fig. 5 have been compiled from records kept at Currie, King Island (lat. 39° 58′, long. 143° 53′). The Commonwealth Bureau of Meteorology, which supplied the data, states that it is reasonable to suppose that temperatures will be similar on the two islands.

The climate is mild, with an absence of extremes. Frost is unknown on the smaller islands such as Fisher Island, but may occur on the main island of Flinders. Light snow has been known to fall on only one occasion on Flinders Island, in August, 1951, when it was noted also on Babel Island.

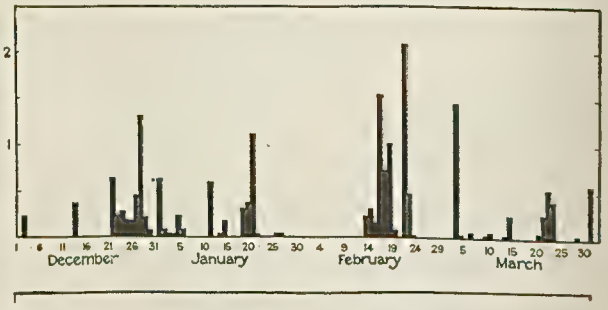


FIG. 4.—Daily rainfall in inches, Pat's River, summer of 1955-56.

(c) *Temperatures in Mutton-bird Burrows*

The micro-climate in the mutton-bird rookeries is somewhat different from that recorded by instruments in the standard meteorological screens. Within the dense *Poa* tussocks, and in *Acacia* and other thickets, which are sheltered from the wind, temperatures may be high. In the mutton-bird harvesting season, in March-April, conditions can be uncomfortably warm for the operatives. Within their burrows, however, the mutton-birds are protected from the extremes of temperature.

The data in fig. 6 were obtained in 1954 from recordings of maximum and minimum thermometers set in empty mutton-bird burrows and in a box screen in an *Acacia* thicket at Potts Point rookery. The mutton-bird burrow selected for analysis was Burrow 90, which lay 17 yards south-east of the box screen. The heavy lines in the graph show the variations in daily maxima and minima in the box screen, and the broken lines those in the mutton-bird burrow. The means have been computed from daily readings for each week from January 14 to May 5, and from November 19 to December 23, 1954.

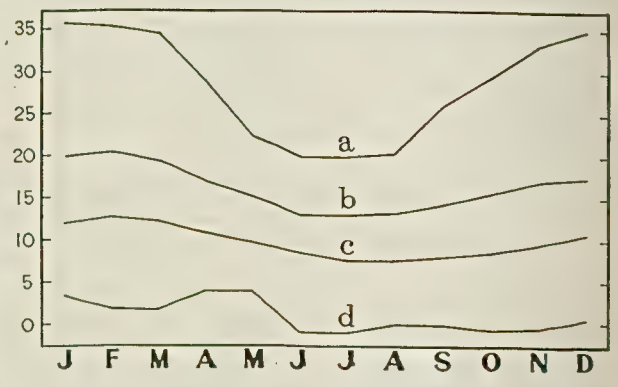


FIG. 5.—Mean monthly temperatures at Currie, King Island, in degrees centigrade, showing absolute maxima (a), mean maxima (b), mean minima (c) and absolute minima (d).

It will be apparent that the temperature in the burrow during the 24 hours oscillates between very narrow limits and that even the seasonal variation is very slight. Outside in the rookery, however, the temperature variations are considerable. The mutton-birds and their chicks are able to exist in a virtually constant environment as far as temperature is concerned.

(d) Mist and Fog

On calm nights, mists may envelope the islands at any season of the year and these may at times be so dense as to reduce visibility to a few yards.

(e) Winds

There is only one wind-recording station in the Furneaux Group, at Pat's River, 13 miles north-west of Fisher Island. Data furnished by the Bureau of Meteorology have been analysed and fig. 7 is a wind-rose for the period during which mutton-birds are present in the breeding area, namely from October to May.

The prevailing winds are from the N.W. to the S.W., and they are strongest from the W. From this direction winds blow with great severity and the gales may last for several days with calm spells between. It is noteworthy that November shows the highest frequency of strong westerlies. This association of boisterous weather with the egg-laying season of the mutton-birds has led to the use of the term "mutton-bird gales" in Bass Strait (cf. Littler, 1910, p. 167). South-easterly weather, though less frequent, can be violent. The least calm period is during the summer, as is the case generally in southern Australia. The autumn improvement starts in March.

For the remainder of the year, June to September, frequency of direction and velocity is generally similar to those for the months depicted in the wind-rose. The principal difference is that N.W. winds are considerably stronger and more frequent in winter, while those from the S.W. are less frequent than in the period October to May.

Westerly weather has a greater effect on Fisher Island than that from any other quarter. There is a considerable fetch across Adelaide Bay from the W. and S.W. and consequently the island shores facing these directions are subjected to relatively heavy wave action and spray effects.

THE MUTTON-BIRD ROOKERIES

The distribution and density of the burrows appears to be controlled by the depth of soil. They are in densest concentration where the soil is of maximum depth, namely 24 inches, and they cut out where the soil covering thins out to between 12 and 9 inches. The birds, have, in fact, utilised as breeding sites all possible parts of the island. The distribution of soil depth has resulted in the burrows being clustered into four main groups (fig. 2), which for convenience of working and record purposes are classified as follows:—

(a) Home Rookery: An area of 311 square yards north-east of the Hut. It is the most numerous rookery with the densest concentration of burrows. In the 1956-57 season 74 of these were occupied. A small group of burrows to the south, the Home Rookery outliers, was not occupied this season. This rookery is almost entirely in the area covered by Tussock grass, *Poa poaeformis*, a plant which dominates the vegetation on all the smaller islands of the Furneaux Group and appears to form the ideal habitat for nesting mutton-birds.

(b) South Rookery: This comprises two small groups of burrows on either side of Snake Gully and occupying 276 square yards of ground. Of these 26 burrows were occupied in 1956-57. Some of the burrows in the western portion are dug into *Tetragonia*-covered ground, but most are among *Poa*.

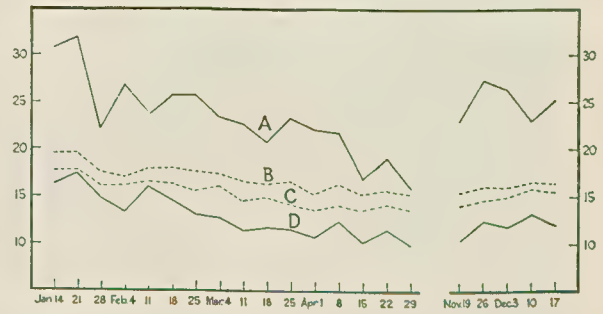


FIG. 6.—Mean weekly temperatures at Fisher Island in degrees centigrade showing maxima in Potts Point Screen (A) and Burrow 90 (B) and minima in Potts Point Screen (D) and Burrow 90 (C). Data for 1954.

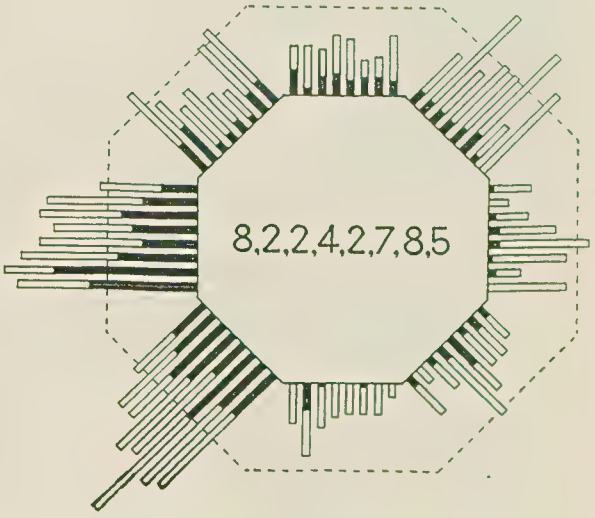


FIG. 7.—Wind-rose for Pat's River showing frequency of wind direction at 9 a.m. (in clockwise order) for each month, October to May inclusive. Solid portion of each histogram shows proportion of wind stronger than 18 m.p.h. (i.e., above Force 4 on the Beaufort Scale). Broken line (outer) octagon is a scale indicating frequency of 12½ per cent. Figures within octagon represent percentage frequency of calms for each month.

(c) Potts Point Rookery: North-east of and very close to the previous colony is a group of burrows, covering an area of 120 square yards, on a slope facing the east; 12 were occupied in 1956-57. Most of the burrows are among *Poa*, some under the shelter of dwarf *Leucopogon*, *Rhagodia* and *Acacia* thickets, and a few in rock crevices.

The total area covered by mutton-bird burrows is 707 square yards, or 7 per cent of the area of the island.

In the *Poa* areas the burrows are tunnelled between, or at the sides, of the tussocks, which form a substantial roof over them. In ground where the tussocks are far apart there is danger of the burrows collapsing if walked on. On Fisher Island the regular examination of the burrows, and consequent handling of the birds, appears to have stimulated the birds to dig longer burrows than on the other islands. Thus on Fisher Island the burrows vary in length from one and a half to nearly six feet, but are mostly between two and four feet. On Cat Island, where the birds are never disturbed, the burrows vary from one and a half to just over three feet in length. The burrows of *Puffinus tenuirostris* are shorter than those of *P. pacificus* and *P. carneipes* and enable the commercial harvesting of the fledglings to be carried on with comparative ease.

On other bird islands in the Sound it is the general practice to run a fire through the tussock areas after the birds leave in early winter. The purpose is to thin out the heavy plant growth and so aid harvesting of the young birds. No management of this type has been attempted on Fisher Island since the investigation began in 1947. However, the denser portions of the *Poa* tussocks in the Home Rookery have been trimmed with a sickle for ease of burrow examination. There has been a tendency for *Tetragonia* to extend over the southern portion of this rookery and by trailing over the *Poa* tussocks to prevent the birds from burrowing in the ground beneath.

On Fisher Island each burrow, whether in use or not, is marked at its entrance by a wooden peg bearing an aluminium plate on which a serial number is punched. In long burrows where the nesting chamber is inaccessible it is impossible, owing to the sandy soil, to use the method adopted at Skokholm Island by Lockley (1942, p. 23) of cutting a sod of turf and using it as a lid. On Fisher Island, where need be, a hole is excavated over the chamber and it is covered over by a wooden trapdoor on which the burrow number is painted.

The birds are present on the island from the last week in September until about the first week in May.

ACKNOWLEDGMENTS

We are indebted to Mr. G. M. Storr for a survey of the island in 1952, his assistance in the analysis of the weather data furnished by the Bureau of Meteorology and for his preparation of the maps and diagrams. Mr. F. Henwood, secretary of the Lady Barron Marine Board, and Trooper L. V. Bailey, of the Lady Barron Police Station, have generously given assistance in the field and provided information.

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II. VEGETATION OF FISHER ISLAND*

INTRODUCTION

Although many specimens have been collected by botanists and casual visitors on the major islands of Bass Strait during the past 150 years, no comprehensive account of the flora has yet appeared. Only a few lists of species are available, and of these the most important are for: King Island [F. V. Mueller in *Vict. Nat.* 4: 140-146 (1888), also *Pap. Roy. Soc. Tasm.*, 1881: 46-48 (1882)]; Deal I. [F. V. Mueller in *Vict. Nat.* 7: 137-139 (1891), also *Pap. Roy. Soc. Tasm.*, 1884: 282-283 (1885)]; Rodondo [J. H. Wills in *Vict. Nat.* 64: 23-24 (1947)], and Flinders Island [various old records in the seven volumes of Bentham's *Flora Australiensis*, 1863-78]. No information has been published on the vegetation of the south coast of Flinders Island (including Fisher Island), Cape Barren or Clarke Islands.

By courtesy of the Wildlife Survey Section, C.S.I.R.O., the writer was enabled to spend a few days at Fisher Island in April, 1954, when notes were made on the land-flora of this small area. Unfortunately his visit coincided with the end of a protracted dry summer season, before any appreciable autumn rains had fallen; nothing was then in flower, and small seasonal plants had completely disappeared. However, in November, 1948, a substantial collection was made by the C.S.I.R.O. of all plants (mostly flowering) that could be found on the island; these, together with supplementary gatherings in December, 1949, and October, 1952, have all been determined by the writer and present a fairly complete picture of the floristic composition. The distribution of principal plant communities was later mapped by Mr. Glen Storr (in fig. 8, "Succulent mat" comprises the *Disphyma, Carpobrotus* and *Pelargonium* communities; "tussock grassland" consists mostly of *Poa; Acacia, Leucopogon, Olearia, Rhagodia* and *Tetragonia* have been grouped together as "dwarf scrub").

For an adequate ecological account of the vegetation, much more time would be needed than was available to the writer in April, 1954, and detailed observations during all seasons of the year would be a prerequisite. Algae and lichens were neither collected nor studied, and the island appears to be singularly poor in larger land-crytogams—no fungi were seen, ferns are absent, and the only mosses noted were *Tortella calycina* (Schwgr.) Dixon and *Bryum billardieri* Schwgr. (both very widespread, hardy species).

GENERAL CHARACTERISTICS OF FLORA

Fisher—being an extremely small (2·1 acres) off-shore island of low relief, with about half the total area consisting of bare granite rock and the remainder with very shallow, friable, "hungry" soil—could not be expected to support a diversified flora, nor to differ appreciably from the nearby mainland. In fact, its plant-cover almost exactly repeats the more impoverished components of the shore-line flora at Lady Barron, only one-eighth of a mile distant, and all the species represented are of wide occurrence on Flinders and most other islands of Bass Strait. Trees and large shrubs are completely lacking, their establishment precluded by the very nature of the environment—poor shallow soil, and exposure to high winds and salt spray. There is no beach-sand, with its characteristic strand vegetation, nor any other formation of particular botanical interest. Marked xeromorphic characters, such as toughness and rigidity or succulence, are evident in the foliage of almost every species represented.

Most vascular plants (at present known to number 33 indigenous and 14 introduced species) are of rare or isolated occurrence, contributing nothing to the facies of the island's vegetation. Only seven species, each in a different genus (viz. *Poa, Disphyma, Carpobrotus, Tetragonia, Acacia, Pelargonium, Leucopogon*), comprise areas large enough to be mapped as more or less pure communities. These dispose themselves in three principal alliances, which are indicated on the accompanying map (fig. 8): 1. *Poa poaeformis-Tetragonia implexicoma* (a kind of tussock grassland), 2. *Disphyma australe-Carpobrotus rossii* (succulent mat-growth), 3. *Acacia longifolia* var. *sophorae-Leucopogon parviflorus* (dwarf scrub formation). Each

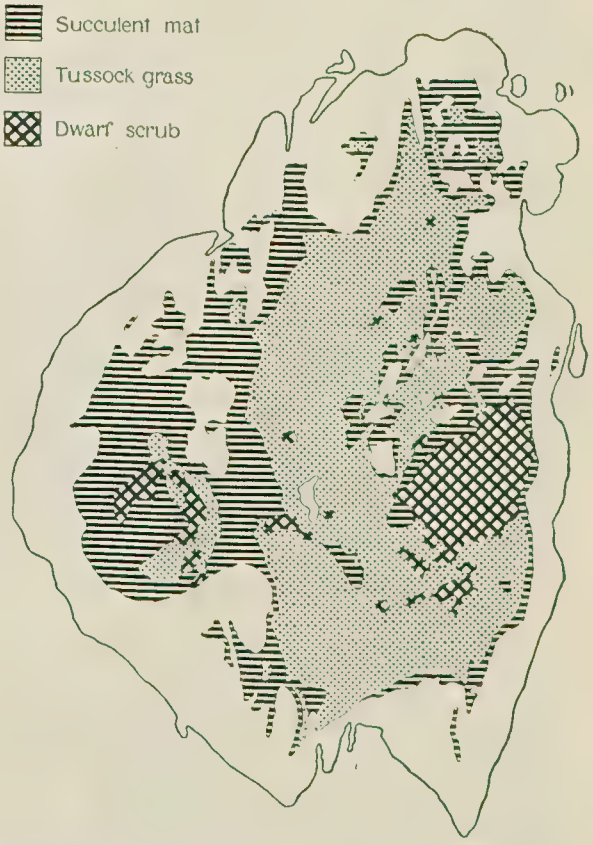


FIG. 8.—Map of Vegetation of Fisher Island, after a survey by G. M. Storr in 1952.

G. M. Storr del.

* By J. H. Willis, National Herbarium of Victoria

of the two dominant species in the alliances usually forms a distinct association, of which the *Poa* and *Disphyma* associations occupy by far the greater areas—together they cover 38 per cent of the island's total area.

Of the 14 alien species, eight are grasses and nine are annuals of wide distribution (almost ubiquitous in coastal areas near settlement); their seed has almost certainly blown onto the island from Lady Barron, except that of *Coprosma repens* which is rare and doubtless attributable to transport by birds (the red succulent fruits being edible).

No attempt has been made to deduce the past botanical history of the area; but Fisher Island probably carried much the same vegetative cover as at present (except for the recently-arrived alien species) when it was joined as a cape or tongue of land to the adjacent granite point of Lady Barron. The absence of such widespread coastal *Compositae* as *Olearia axillaris* (Coast Daisy-bush), *Calocephalus brownii* (Cushion Bush), *Senecio lautus* (Variable Groundsel) and *Sonchus megalocarpus* (Dune Sowthistle) is remarkable.

COMPARISON WITH OTHER MUTTON-BIRD ISLANDS

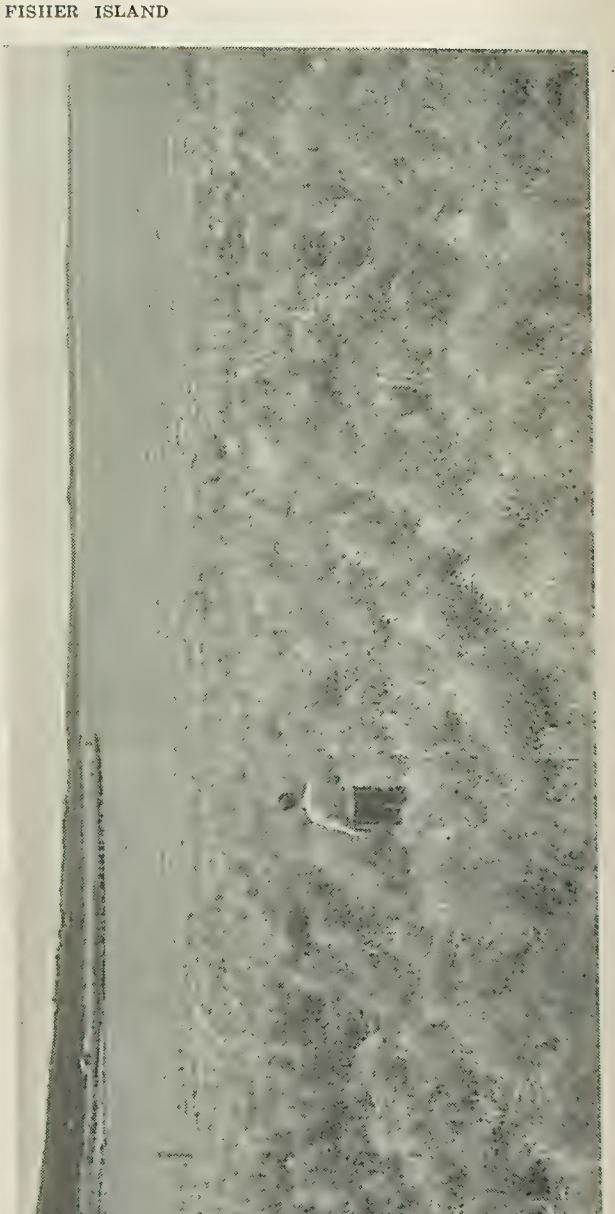
The number of indigenous species (33) is far too limited for any useful floristic analysis; suffice it to note that 19 families of vascular plants and 30 genera (almost a genus per species) are present. The chief families, in order of species representation, are: *Compositae* (6), *Gramineae* (4), *Ficoidaceae* (3), *Chenopodiaceae* (3). Species occupying the greatest area are those which predominate on other small islands of Bass Strait.

Almost half the species (15) are also of wide occurrence on islands of the Recherche Archipelago (W.A.) inhabited by shearwaters (mutton-birds); these are prefixed by the italic letter "R" in the list that follows. Three other plants (*Poa poaeformis, Crassula sieberiana* and *Acacia longifolia* var. *sophorae*) are replaced by related species in the Recherche (viz. *P. australis, C. miriamae* and *A. cyclopis* respectively). Whereas most shearwater burrows on Bass Strait islands (including Fisher) are excavated under tussock-grass, those of the Recherche islands occur beneath *Carpobrotus, Tetragonia,* or amongst roots of the small umbrageous tree *Melaleuca pubescens* ("moonah"); none of the species appear to be in any way adversely affected by the birds' tunnelling activities. Tussock-grass (*Poa australis*) is a very minor component of the Recherche flora, occurring only in small isolated patches.

PRINCIPAL PLANT COMMUNITIES

Disphyma australe

This extremely succulent perennial (noon-flower or "pigface") occupies ± 1540 square yards or 14 per cent of the island area, occurring as extensive mats around the whole periphery and being particularly well developed in the south-western sector of Fisher Island where it forms a pure (monospecific) community. Salt-tolerant to a high degree, *D. australe* is the chief pioneer among higher plants. It colonizes the bare granite surfaces immediately above high-water mark—where-



—Photo: K. A. Hindwood.

Fig. 9.—View on Fisher Island showing Poa poaeformis tussock area; looking north-east towards Lady Barron jetty.

ever seeds can gain a foothold in small cracks and depressions of the rock—and is frequently wetted by salt water. *Disphyma* would certainly aid in intercepting and stabilizing wind-blown sand, thus adding to the soil derived from parent rock and, also by its own litter of dead foliage, &c., providing a shallow substrate in which grasses and finally shrubs could flourish. It is succeeded on the landward side either by *Carpobrotus rossii* (a closely related but larger and less salt-tolerant succulent trailer, with which it forms an alliance) or by the tussock-forming grass *Poa poaeformis* (seq. q.v.).

Poa poaeformis

The Sea Tussock-grass occurs either as a pure dense community usually one to two feet high—in which most of the island's mutton-bird burrows are situated—or more sparsely in varying mixture with other herbs, and occupies ± 2530 square yards (24 per cent of the island area); it is much more extensive than all other plant associations combined ,being present in all parts of the island except for the periphery and a considerable area of *Disphyma* in the south-west portion. *Poa* gives way to low shrubberies of *Acacia* (in the east) and *Leucopcgon* (in scattered clumps) wherever aspect and sufficient soil have permitted the development of these taller, woody, sclerophyllous perennials. An unstable alliance is formed with the trailing, succulent *Tetragonia implexicoma* which may predominate to the exclusion of grass in small patches.

Acacia longifolia var sophorae

Depauperate bushes (four to six feet high) of this normally arboreal wattle comprise one continuous thicket covering 350 square yards (3·3 per cent of island area) on the more sheltered eastern side—at Potts Point, and nowhere else. An occasional shrub (flowers not available) of what appears to be *Acacia mucronata* occurs in mixture with the dominant *A. longifolia* which, apparently, is the climax community on Fisher Island. These plants are not healthy and have been dying back from the branch-tips for some years, at least since 1950 (see note under "Evidence of Change").

Leucopogon parviflorus

Typically of sand dunes, this coastal heath occurs on Fisher Island in a very stunted form (two to four feet high). Distribution is by no means continuous, as in *Acacia*, but the *Leucopogon* is broken into isolated clumps (seldom more than 10 square yards in extent) scattered through the central, south-eastern and south-western parts of the island. The total area occupied is only about 125 square yards or 1·2 per cent of the whole island. *Leucopogon* and *Acacia* constitute an alliance, but each is present as a more or less pure community. Two other shrubs, *Olearia stelluiata* and *Rhagodia baccata*, are minor associates.

The glassworts *Salicornia australis* and *Arthrocnemum arbusculum*, collectively known as "samphire", are to be found occupying two small depressions (just above high-tide level), one on the eastern side of North Point, the other south of Oystercatcher Rocks—the only occurrences of this pioneer halophytic alliance which is such a conspicuous feature on tidal flats and salt-marshes throughout southern Australia.

EVIDENCE OF CHANGE

From the existing distribution of communities, it seems most likely that succession toward a development of woody shrubs would have occurred in the following stages, beginning with a lithosere:

Probably the vegetation has long ago reached a state of equilibrium, and very slight fluctuations in climate (excessive gales, persisting high summer temperatures, water availability, &c.) may conceivably bring about a reversal in the stages of succession. The vigorous growth (and ascendancy) of *Poa* and *Tetragonia* in November, 1956, in places where *Acacia* had died out extensively, lend support to such a hypothesis. Both *Acacia* and *Leucopogon* have been steadily dying back from the branch-tips, with minor recuperations, ever since 1950. The causes of this retrogression are not at present clear: unusually long dry spells late in summer, during the last few years (especially February-May, 1954), combined with severe westerly winds in late winter may have hastened the deterioration. Much dead and dying *Disphyma* is to be found in the extreme south-western sector, and by March, 1957, die-back was also apparent in *Carpobrotus* (especially that above Starling Rock), *Tetragonia* and *Rhagodia* (an exceedingly hardy and usually wind-tolerant semi-shrub).

None of the radical changes associated with fire are to be seen on Fisher Island which has not been burnt for many years, certainly not since 1947—otherwise it might be expected to yield *Senecio capillifolius* Hook. f. (Fennel Groundsel or "fireweed"), a tall showy herb with very finely dissected foliage. This plant appears in the wake of fire, grows vigorously among tussocks of *Poa poaeformis* and lasts only a couple of seasons; it is abundant on nearby Little Green and Great Dog Islands, which are fired periodically to facilitate the operations of mutton-birders, and extends along the north-east coast of the Tasmanian mainland. The species is little known and apparently endemic in this portion of Bass Strait. Two other members of the same genus, *S. linearifolius* and *S. glomeratus*, collectively known as "fireweeds", are of very limited occurrence on Fisher Island.

LIST OF VASCULAR PLANTS ON FISHER ISLAND

Three prefixing signs have been used, as follows:
* Naturalized alien plants.
r. Species of rare occurrence.
R. Species also represented in the Recherche Archipelago, W.A.

Monocotyledoneae

Gramineae (Grasses)

* Briza maxima *L.*, 1753—Large Quaking-grass.
* Dactylis glomerata *L.*, 1753—Cocksfoot.
Poa poaeformis (*Labill.*) *Druce*, 1917—Sea Tussock-grass.
*r.** Vulpia bromoides (*L.*) *S. F. Gray*, 1821—Squirrel-tail Fescue.

* Bromus mollis *L.*, 1762—Soft brome.
*r.** Parapholis incurva (*L.*) *C. E. Hubbard*, 1946—Coast Barb-grass.
*r.** Avena sativa *L.*, 1753—Oat.
* Aira caryophyllea *L.*, 1753—Silvery Hair Grass.
* Holcus lanatus *L.*, 1753—Yorkshire Fog.
Dichelachne crinita (*L. f.*) *Hook. f.*, 1853—Long-hair Plume-grass.
r. Deyeuxia quadriseta (*Labill.*) *Benth.*, 1878—Reed Bent-grass.
Stipa teretifolia *Steud.*, 1854—Prickly Spear-grass.

Juncaceae

r. Juncus pallidus *R.Br.*, 1810—Pale Rush.

Liliaceae

R. Dianella revoluta *R.Br.*, 1810—Black-anther Flax-lily.
r. Bulbine semibarbata (*R.Br.*) *Haw.*, 1821—Leek Lily.

Orchidaceae

R.r. Microtis unifolia (*Forst. f.*) *Reichenb. f.*, 1871—Common Onion-orchid.

DICOTYLEDONEAE

Polygonaceae

R. Muehlenbeckia adpressa (*Labill.*) *Meissn.*, 1840—Climbing Lignum.

Chenopodiaceae

R. Rhagodia baccata (*Labill.*) *Moq.*, 1840—Seaberry Saltbush.
R.r. Salicornia australis *Soland. ex Benth.*, 1870—Austral Glasswort.
r. Arthrocnemum arbusculum (*R.Br.*) *Moq.*, 1840—Samphire Glasswort.

Ficoidaceae

R. Disphyma australe (*Soland. ex Ait.*) *J. M. Black*, 1932—Australian Noon-flower.
R. Carpobrotus rossii (*Haw.*) *N.E. Br.*, 1928—Karkalla (Pigface).
R. Tetragonia implexicoma (*Miq.*) *Hook. f.*, 1856—Bower Spinach.

Portulacaceae

R.r. Calandrinia calyptrata *Hook. f.*, 1840—*Pink* Purslane.

Caryophyllaceae

r. Spergularia media (*L.*) *C. Presl*, 1826—Coast Sand-spurrey.
* Silene anglica L., 1753—French Catchfly.

Ranunculaceae

R.r. Clematis microphylla *DC.*, 1817—Small-leaf Clematis.

Cruciferae

R. Lepidium foliosum *Desv.*, 1814—Coast Pepper-cress.

Crassulaceae

Crassula sieberiana (*Schult. & Schult. f.*) *Druce*, 1917—Sieber Crassula.

Mimosaceae

Acacia longifolia (*Andr.*) *Willd.*, 1806, var. sophorae (*Labill.*) *F. Muell.*, 1863—Coast Sallow Wattle.
r. Acacia (?) mucronata *Willd. ex H. Wendl.*, 1820—Variable Sallow Wattle.

Papilionaceae

* Trifolium dubium *Sibth.*, 1794—Suckling Clover.
* Melilotus indica (*L.*) *All.*, 1785—Small-flower Melilot (King Island Clover).

Geraniaceae

R. Pelargonium australe *Willd.*, 1800— Australian Storksbill.

Oxalidaceae

R. Oxalis corniculata *L.*, 1753—Creeping Wood-sorrel.

Umbelliferae

R. Apium prostratum *Vent.*, 1804-05—Sea Celery.

Epacridaceae

R. Leucopogon parviflorus (*Andr.*) *Lindl.*, 1833—Coast Beard-heath.

Rubiaceae

*r.** Coprosma repens *A. Rich.*, 1832—Hedge Coprosma (Looking-glass Bush).

Stylidiaceae

r. Stylidium graminifolium *Sw. in Willd.*, 1805—Grass Trigger-plant.

Compositae

r. Lagenophora stipitata (*Labill.*) *Druce*, 1917—Common Lagenophora (Bottle-daisy).
Brachycome diversifolia (*R. Graham ex. Hook.*) *Fisch. & C. Mey.*, 1835, var. maritima *Benth.*, 1867—Sea Daisy.
Olearia stellulata (*Labill.*) *DC.*, 1836—Starry Daisy-bush.
Helichrysum bracteatum (*Vent.*) *Andr.*, 1805—Golden Everlasting.
r. Senecio linearifolius *A. Rich.*, 1834—Fireweed Groundsel.
Senecio glomeratus *Desf. ex Poir.*, 1817—Cluster Fireweed.
*r.** Hypochaeris radicata *L.*, 1753—Cat's-ear (Flat-weed).
* Sonchus asper (*L.*) *Hill*, 1769—Spiny Sow-thistle (Rough Sow-thistle).

[Basonyms and synonyms have been omitted from this list.]

III. INTERTIDAL ECOLOGY OF FISHER ISLAND*

INTRODUCTION AND NOMENCLATURE

Throughout this paper the nomenclature used is that of Stephenson & Stephenson (1949) and Guiler (1953). The author of each species is mentioned only once.

This paper is the 12th of a series on various features of the intertidal ecology of Tasmania and is the first to deal with a locality in the Bass Strait area. A visit was made to the north-eastern end of Tasmania at Eddystone Point and the observations made during this visit are incorporated into the discussion at the end of this paper. Eddystone Point was visited in January, 1957. Visits were made to other islands near Fisher Island, namely Little Green Island, Big Dog Island, Woody Island, Babel Island and Cape Barren Island.

ZONATION

The zonation over most of the island follows one basic pattern but there are important variations to this general zonation at several places on the island. Thus it is desirable to consider the zonal patterns at various localities on the island rather than attempt to generalize regarding the zones found on the shore as a whole.

Before commencing upon a general description of the plant and animal zones it is necessary to consider the wave action on Fisher Island which forms part of the inner group of the Franklin Sound Islands. There is no exposure to wave action of oceanic intensity and no ocean swell is experienced on the shores of the island. The greatest exposure to wave action is experienced when westerly or southerly winds blow, but the "fetch" is small and an uncomfortable slop, composed of waves of short length and low amplitude, is the worst sea encountered. The south shore, from South Point to The Fingers, is the most exposed part of the island with lesser exposure on the west coast and least exposure being experienced on the east and north coasts. The latter is the most sheltered part of the island. The tidal phenomena and currents have been treated above by Serventy.

At South Point, a low rounded prominence where there is some wave surge over the Point but not much spray, the zonation is:

Telostichistes parietinus (L.) Norm.
Parmelia conspersa (Ehrh.) Ach.
Parmelia perlata (L.) Ach.
Myxophyceae
Littorina unifasciata (Gray)
Chthamalus antennatus + *Littorina unifasciata*
Chthamalus antennatus + *Melanerita melanotragus* (Smith)
Chthamalus antennatus + *Bembicium auratum* (Quoy & Gaimard)
Chthamalus + *Chamaesipho columna* (Spengler)
Chamaesipho + *Chthamalus* + *Austromytilus erosus* (Lam.)
Galeolaria caespitosa (Lam.) + *Gelidium australe* J. Ag.
Hormosira banksii (Turn.) Decaisne—*Pyura stolonifera* (Heller)
Cystophora spp.

The zonal pattern here is rather complex and some other species may assume dominance over a very restricted area. The *Littorina* belt is not invaded by other species in this region, but the belt formed by *Chthamalus* is composed of a series of sub-belts any one of which may be locally dominant. *Littorina unifasciata* invades the top of the *Chthamalus* belt. Also found in the top of the belt are *Melanerita melanotragus* and *Bembicium auratum*. These three species show little, if any, differentiation into vertical belts but at a glance give the impression of being organisms of zonal significance. However, they give a false picture if considered as such because the individuals of these species form aggregations and it is these aggregations in the restricted area under consideration which give the appearance of belts.

The small barnacle, *Chamaesipho columna*, becomes more common in the *Chthamalus* belt, although *Chthamalus* is still found as the dominant organism. The lichen, *Lichina confinis* (Mull.) Arg., as well as *Bembicium*, *Littorina* and *Melanerita* are common at this level. These four latter species soon cut out, leaving *Chthamalus* still present. A small mussel, *Austromytilus erosus*, is found at this level but it is very patchy in distribution and cannot be considered as a belt forming species. The barnacles cease to be the dominant species on the shore at a slightly lower level where *Galeolaria caespitosa* becomes the dominant species. The latter occurs sparsely in the lower *Chamaesipho* belt and is accompanied by *Rivularia australis* (Harv.).

The *Galeolaria* belt is noticeable for the very close association of this species with the alga *Gelidium australe*. These two species are not found living apart from each other on the shore. The *Galeolaria* tubes are not found in the dense masses which are usually so characteristic of this species but they form a close cover to the rocks (Plate I). Correlated with the absence of dense *Galeolaria* clusters is the lack of species commonly found living in the masses of worm tubes such as *Ibla quadrivalvis* Cuvier, *Kellia australis* (Lam.) and various polychaetes.

The *Galeolaria* belt is replaced by a *Hormosira* belt which has some *Galeolaria* tubes scattered amongst the plants. The most interesting feature of the *Hormosira* belt is that it is characterized in its lower parts by a number of *Pyura stolonifera*, which form a colony of appreciable size. The algae of the Infralittoral Fringe occur below the *Pyura*.

The rocks beside the Blow Hole, on the southern shore of the island, show a different zonation, largely on account of the topography of the coast. In this region there are boulders in the Infralittoral Fringe which give rise to spray which is swept on to the island by the prevailing wind. Consequently, the zonation has been altered to:

Littorina unifasciata
Bare rock
Chthamalus antennatus + *Bembicium auratum*
Lichina confinis + *Chthamalus antennatus*
Chamaesipho columna
Cellana solida (Blainville)
Galeolaria caespitosa
Hormosira banksii
Cystophora spp.

* E. R. Guiler, Department of Zoology, University of Tasmania

However, this type of zonation is by no means found over all of the southern shore. The *Littorina* belt is absent over most of this shore-line but the barnacles reach their most dense colonization on this shore, together with *Lichina*. The *Myxophycean* and barnacle belts are particularly well developed on the Lower Midden Rock. A prominent absentee from the shore at Lower Midden Rock is *Bembicium*, the species being rare, even in the barnacle belt, however, *Bembicium* becomes more numerous further to the east on the rocks below the Notice Board. Reading from top to bottom at this place the belts are formed by *Myxophyceae, Chthamalus* with *Lichina, Chthamalus + Lichina + Chamaesipho, Chamaesipho + Lichina Chthamalus, Chamaesipho, Cellana, Galeolaria, Hormosira, Cystophora.*

The zonation on the eastern shore shows some differences from that on the southern, the most important difference being the absence of a barnacle belt and the great reduction of the *Myxophyceae* band. On the rocks near North-East Boat Harbour, *Littorina* forms the top belt of the intertidal region, followed by *Bembicium* together with *Austrocochlea concamerata* (Wood), which in turn is replaced by *Cellana*. The belts below *Cellana* are the same as those on the Lower Midden Rock.

There is a change of substratum at the Slipway on the north-western side of the island which leads to an important modification of the zonation. The rocks are replaced by an almost level part of the shore which consists of a muddy sand with stones imbedded in it. The clefts between the surrounding rocks have some sand in them and these clefts together with the sandy area at the Slip, support colonies of the mussel, *Austromytilus erosus*. These mussels have striae extending the length of the shell and are very readily distinguished from individuals of the same species found on the more exposed South Point, which have these striae more less eroded. The mussel belt lies between the *Cellana* and *Hormosira* belts. The *Cellana* belt is partly suppressed, being represented by individuals around the edges of the sandy area.

The North Point zonation is slightly different from that to be seen on the other shores in that a very feebly developed *Corallina* belt occurs below the *Hormosira*. The Infralittoral Fringe algae are all of the genus *Cystophora*, namely *C. cephalornithos* (Lab.) J. Ag., *C. torulosa* (R.Br.) J.A., *C. retroflexa* (Lab.) J. Ag. and *C. uvifera* (Ag.) J.Ag., and they are replaced in the Infralittoral by *Cymodocea* sp. The *Littorina* and *Chamaesipho* belts are well developed at North Point.

NOTES ON SOME SPECIES

The study of a restricted area such as Fisher Island reveals many interesting points regarding the factors controlling the distribution of the species lying on the shore, particularly in their relation to wave action and its associated spray and surf exposure. A more true pucture of the effect of these factors can be gained in a small area where the wave action is slight rather than on a large part of an exposed coastline, since with a restricted amount of wave action, slight variations in its intensity give a more obvious alteration in the distribution of intertidal organisms. I propose to discuss the distribution of some of the common intertidal species of Fisher Island.

(a) *Littorina unifasciata*

Littorina is sporadically distributed around the island. The *Littorina* belt is absent from North Point, North-East Point, most of the Western shore south of the Slip to the Lower Midden Rock where there is an isolated patch of *Littorina*. This species is absent from Lower Midden Rock to near South Point and it is also absent from north of Potts Point to North Point but with an isolated group on a level platform to the north of Starling Rock.

Littorina is most numerous from South Point to Starling Rock on the East Coast of the island. This part of the shore has a well developed *Littorina* belt which ends quite sharply at Potts Point but there is a small patch, mixed with *Bembicium*, on the level or gently sloping rocks. Other places with well developed *Littorina* belts are North-East Boat Harbour, at the Slip, the Blow Hole and South Point.

The explanation of the apparently sporadic distribution of this species lies in its relation to the spray encountered on the shore, though the gregarious behaviour of the littorines may play some part in limiting the distribution of the species. At North-East Boat Harbour there is no spray break, that is to say, the rocks slope upwards directly from low-water mark without any boulders, clefts or hindrances to prevent the spray and waves reaching up the shore. At the Slip and the eastern shore a similar situation prevails. The western shore is steeper than the northern and eastern shorelines and the topography is such that the spray from Infralittoral Fringe boulders may not reach the level of the *Littorina* population, particularly during the periods of relatively calm, warm summer weather.

The direct mechanical effect of wave action probably is not responsible for the absence of the littorines from the Lower Midden Rock and southern parts of the island. The substratum is granite which weathers into a rather smooth rock over which waves could sweep with considerable force, but although I have been on the island during a moderate gale, the wave action was never great enough to sweep the littorines off the rocks. It appears that again the spray from rocks of the Infralittoral Fringe must not reach the level normally occupied by the *Littorina* belt during periods of calm.

There is a patch of *Littorina* on the rocks near the Blow Hole which is in contradiction to the above suggestions, but this patch may well be maintained by the slight amount of spray from the Blow Hole.

South Point is the most exposed part of the island and is exposed to considerable spray. The direct mechanical effect of the waves is reduced by offshore boulders but it is still sufficient to show that this factor, within the maximum limit experienced at Fisher Island, is not one directly controlling the distribution of this gastropod.

It was mentioned earlier that the gregarious habit of this species may have some control over its distribution. It was noted during my visit in December, 1956, that *Littorina* congregated in clusters, 20 being the largest number noticed. Individuals living singly on the rocks were rare, groups of three being the most common aggregations of small numbers of individuals. This habit would lead to a slow spread of the species.

The most dense population of *Littorina* is on the eastern coast where a population density of 12 to 14 individuals per 10 cm. square is reached.

(b) Bembicium auratum

At first glance it would appear that interspecific competition exists between this species and *Littorina unifasciata*, since, in general, these two species do not commonly occur together on the island. There is a very significant difference in the amount of air exposure which these two species can tolerate, *Bembicium* being less tolerant to air exposure than *Littorina* (Guiler, 1950). Further to this, a patch of rock was cleared of *Littorina*, leaving *Bembicium* at the lower level and this patch was not invaded by *Bembicium*. A cleared area in the *Bembicium* belt was invaded to some extent by *Littorina*, but the argument in this case is somewhat different since *Littorina* may be found on the shore as low down as the barnacle belt. There may be a population pressure exerted by *Littorina* upon *Bembicium* but there is no pressure in the other direction.

Bembicium and *Littorina* are found at the same level to the north of Potts Point. However, with this exception, it is true to say that these two species do not occur at the same tidal level, but they do occur on the same part of the shore at different levels, e.g., most of the eastern shore from South Point to Potts Point.

This species is widely distributed on both the eastern, northern and western shores of the island, but it is practically absent from the southern shore, apart from a few individuals in the barnacle belt near the Blow Hole and a very restricted area beside the Blow Hole in which there is a belt formed by this species. It may be concluded that this species thrives in places where *Littorina* is absent, probably the result of wave splash and spray giving optimum conditions for *Bembicium* but not being sufficient to enable the Supralittoral Fringe dwelling *Littorina* to exist. It must be noted that *Littorina* may exist in patches on the same part of the coast as *Bembicium*, e.g., at North-East Boat Harbour and the two may even form belts at different levels on the same shore as at Potts Point.

Bembicium auratum differs in habit from *Littorina* being usually solitary. The density of population on the eastern shore may be taken as general for the whole island and is approximately 1·03/10 cm. square.

In most places *Bembicium* extends down into the barnacle belt, though in a few, usually spray swept places, the barnacles reach up into the *Bembicium* belt. *Lichina* may also extend into the *Bembicium* belt, though this does not occur on the eastern shore.

(c) Melanerita melanotragus

This small gastropod is common on the eastern shore but is absent from the southern and western sides of the island. It is found on the northern shore but it is not as numerous on this part of the island as on the eastern side.

Melanerita is of little value as a zonal organism since it is found to have a tidal periodicity in its activity, *Melanerita* adopting a semi cryptic habit during the high-water period. At high water I counted 70 individuals living in open places on the shore between South Point and Potts Point. At low water when the part of the shore which they inhabit below the *Bembicium* belt was exposed, as many as 60 individuals were counted around one pond at Potts Point, and all of the eastern side was similarly populated.

In March, 1954, it was found that *Melanerita* lived in clusters of 10 or more individuals. During by visit in November, 1956, the species was definitely solitary in habit, except when semi-cryptic below stones at the high-water period.

At South Point there are rocks and stones at about the level of the *Galeolaria* belt and these furnish a suitable habitat for *Melanerita* which is very common hereabouts. Stones at North Point also have a *Melanerita* population dwelling below them.

The absence of *Melanerita* from the wave exposed southern and western shores is undoubtedly correlated with the wave action encountered there. *Melanerita* is common on the rocks at Gunter's Bay, which is part of Adelaide Bay on the adjoining Flinders Island.

(d) The Belt-forming Barnacles

The barnacle belt is nowhere well developed on the island, though considerable populations are found in patches on the Lower Midden Rock, North-East Point, North Point and at South Point. Local restricted areas of barnacle population are encountered in places where there is some spray. The sheltered eastern shore has a very poor barnacle fauna.

The barnacle belt, when present, is found between the *Bembicium* belt, or at South Point, the *Littorina* belt, and the belt dominated by the large limpet *Cellana solida*. An exception to this occurs at South Point where the *Cellana* belt is absent and the barnacle belt passes down into a mixed barnacle-mussel belt, ultimately altering very sharply into the *Galeolaria* belt.

There are only two species of barnacles forming the barnacle belt. The upper part of the belt is dominated by *Chthamalus antennatus*. This belt is often associated with *Littorina* in its top parts and *Bembicium* in the lower, with *Melanerita* occurring at the same level as *Bembicium* on the East Coast and at South Point. There is usually some mixing of *Chthamalus* with the other species of barnacle, *Chamaesipho columna*, which is the belt forming barnacle in the lower part of the barnacle belt. This latter species may have *Melanerita*, *Bembicium* and even *Littorina* living at the same level but is more frequently characterized by a patchy growth of *Lichina confinis* (Meull.) Arg. The lower limit of the barnacle

belt is generally sharp though this may be obscured by *Lichina* or by *Rivularia*, especially on spray soaked places.

In 1954 I noted that there had been a large spatfall of barnacles at South Point as well as at Potts Point. The spat at the latter place was unable to survive in any large numbers but at South Point was apparently successful. During the earlier visit, there were no adult barnacles at Potts Point though there were adults on South Point. The density of barnacle population at Potts Point was 17 *Chthamalus* and 500 *Chamaesipho* in a 10 cm. square, though just north of South Point these figures dropped to 10 and 227 respectively. The counts were made in 1954.

It can be stated that generally the barnacle population is at its highest on places with spray exposure, though some local dense populations occur on sun-sheltered rocks, e.g., at North Point.

(*e*) *Cellana solida*

This large limpet is the most conspicuous feature of the Midlittoral on the island (Plate II). It forms a band which is practically continuous around the island, being broken only at South Point and somewhat diminished by the altered substratum at the Slip.

The limpets are selective as regards their habitat and do not favour places with a large number of small stones. One of their requisites appears to be a fairly smooth surface of sufficient extent to enable them to graze without hindrance by clefts or other stones.

Cellana extends as high as the *Bembicium* belt but it is usually found in clefts or living in the shade of rocks at this level, though one specimen was found living on an open surface in the *Bembicium* belt near North Point. The lower limit of the *Cellana* belt is very sharply marked by the top of the *Galeolaria* belt, the rough surface presented by the worm tubes being unsuited to the grazing habit of the limpets.

In November, 1956, there were approximately 4140 *Cellana* living on Fisher Island. Six hundred and ten of these lived between North-East Boat Harbour and South Point, 1712 were found between South Point and The Fingers while 1817 occupied the shore between The Fingers and North Point. These figures show clearly that the limpets are found in greatest numbers on the shores where there are boulders and large stones at the required tidal level which furnish them with a grazing surface. The gently sloping, almost boulder free, eastern shore supports the smallest population of limpets.

The limpets live on the sun exposed faces of rocks or in the shade of overhangs, boulders, &c. There are probably more limpets living in the latter habitat than in the former. I am unable to decide whether this is due to a love of shade or to a concentration of food supply in these places. *Cellana* does not live in dark places, possibly because of a lack of their algal food supply. This points to the possibility that the shade concentrations of this species may be a response to the availability of food.

The *Cellana* belt is not found at South Point. In 1954 a belt dominated by this limpet did occur on this Point. In December, 1956, *Cellana* cut out about three and a half metres to the north of the Point (Plate II). One possible reason for the absence of the limpet is the presence of *Austromytilus erosus*. This mussel was not recorded from this point in 1954 and the dense clusters of the species could well offer a habitat unsuited to *Cellana*. However, this is only a part explanation of the absence of the limpet from the Point since there are neither mussels or limpets on a large part of the shore between the Point and the part of the shore where the *Cellana* belt commences. It is hard to credit that wave action may play a part in limiting the distribution of *Cellana* since the limpet is found in equally exposed situations on Lower Midden Rock. Also, since the limpet was found on the Point in 1954, why would wave action be a factor in 1956 but not in 1954? The reason for the change in the zonation is to be sought in other directions (see discussion below).

Individuals of *Cellana solida* frequently have other species living on their shell. The algae so found are *Enteromorpha* sp. and *Bostrychia mixta* H. & H. The barnacle, *Chamaesipho columna* is found on limpet shells, particularly those living in the lower part of the limpet belt on the southern coast. *Bembicium auratum* may also live on the shells as does *Siphonaria diemenensis* (Quoy and Gaim.). Limpets can often be recognized by the algal tufts which live attached to *Cellana* and to the only other large limpet, *Patelloida alticostata* (Angas).

The limpet belt also has other species occurring in it. *Galeolaria caespitosa* is found in this belt but it is always semi-cryptic in habit and does not form a coating to the rocks except under overhanging boulders. Another limpet, *Patelloida alticostata* is found in the lower part of the *Cellana* belt, though it is more frequently found on that part of the shore dominated by *Galeolaria*. Two species of *Siphonaria* are found with *Cellana* but neither are in any sense dominant. They are *Siphonaria diemenensis* and *Siphonaria funiculata* Reeve, the latter being the scarcer species. Other species are *Cominella lineolata* (Lam.), *Austrocochlea constricta* (Lam.), *Austromytilus erosus*, *Colpomenia sinuosa* (Roth.) Derb. and Sol., *Rivularia australis* and *Enteromorpha* species. The latter species is common in places where there is water seepage.

The shells of *Cellana* are usually fairly heavily eroded. This is especially true of the individuals in air exposed situations and also the large, and presumably old, individuals found highest on the shore. At low levels the shells tend to be less eroded. Young small individuals, about 2 cms. in length, live at the lowest part of the *Cellana* belt and are frequently not eroded.

(*f*) *The Galeolaria-Hormosira Belt*

I propose to consider these two species together since they are usually closely associated on the shores of Fisher Island. The *Galeolaria* belt is continuous around the island but is not as well developed on the western as on the eastern shore. This is in accordance with earlier observations

on this species which has been found to be tolerant of wave exposure. *Galeolaria* does not form the thick encrustations seen at times on other parts of the Tasmanian coast, but is in the nature of a continuous cover to the rocks. As a consequence of this, the rich fauna of the *Galeolaria* belt is absent. The most remarkable feature of this belt is the close association between *Galeolaria* and the alga *Gelidium australe*. This seaweed forms conspicuous yellowish tufts in the *Galeolaria* belt.

Hormosira is also continuous around the island, forming a narrow belt at the bottom of the Mid-littoral region. This belt is widest at the Slip and North-East Point, where the substratum is nearly horizontal at the level occupied by *Hormosira*. This is the only place where the *Hormosira* belt is of sufficient width and where there is also suitability of substratum for the development of a varied fauna.

The following species occur on or under the stones at North-East Point:—*Arca* (Barbatia) *pistachia* Lam., *Lepsithais vinosa* (Lam.), *Zeacumantus diemenensis* (Quoy & Gaim.), *Zemitrella acuminata* (Menke), *Austrodrillia beraudiana* (Crosse), *Cymatiella verrucosa* (Reeve), *Mitra* sp. juv. (?*rhodia* Reeve), *Austrocochlea constricta, Austrocochlea concamerata, Acanthochiton sueurii* (Blainville), *Ischnochiton* sp. juv., *Modiolus pulex, Bembicium auratum.*

At the Slipway there is a patch of mussels embedded in sand. These mussels are *Modiolus pulex* Lam. Below them are the Grapsid crab *Leptograpsus variegatus* (Fabr.), *Ibla quadrivalvis* Cuvier, *Cominella lineolata, Lepsithais vinosa, Sabia conica* Schumacher, *Melanerita melanotragus, Micrastraea aurea* Jonas, *Serpulorbis sipho* (Lam.), *Fax tenuicostata* (Tenison-Woods), *Sypharochiton maugeanus, Cryptoplax iredalei* (Ashby.), *Hymeniacidon perlevis* (Montagu), *Patiriella exigua* (Lam.), *Alabes rufus* (Macleay).

The *Hormosira* belt passes into a very poor *Corallina* belt which may only be two inches in vertical height on the eastern shore. There are no shelves, &c., at a level suitable for the development of the *Corallina* belt, the *Hormosira* passing directly into the algal belt, *Cystophora* spp., or the Infralittoral Fringe. However, the bottom part of the *Hormosira* belt contains a large number of ascidians of the species *Pyura stolonifera* (Herdman). The *Pyura* is not present in sufficiently large numbers to form a belt, but its presence on South Point indicates that the wave action there, and nowhere else on the island, is sufficient to maintain this species. Another species found on South Point is a remarkable sponge, grey in colour 25-30 cms. in diameter with its surface raised into ridges on which the osculae are placed. A large Conid shell, *Floraconus anemone* (Lam.) together with two small shells of the same species were found in amongst the *Pyura* tests.

(g) The Austrocochlea Species

Two species of *Austrocochlea* are found between the tides on Fisher Island. The most conspicuous of these is the large *A. constricta*, in which the shell is heavily ridged. This species is common at North Point and at places on the eastern shore between North Point and Potts Point. It also occurs at Western Boat Harbour.

The second common species of *Austrocochlea, A. concamerata*, is found frequently with *A. constricta* but also living in places from which *constricta* is absent. Like *constricta*, it is intolerant of wave action and is found only on the eastern shore from Potts Point to North-West Boat Harbour. Both these species are found amongst the large boulders at South Point and in gullies on the western coast.

(h) Other Species

The only barnacles which are common on Fisher Island, other than the two species mentioned above, are *Tetraclita purpurascens* (Wood) and the stalked *Ibla quadrivalvis* (Cuvier). The former species is always semi-cryptic in habit being found under boulders, in clefts, between rocks and in extremely sun-shaded places. Individuals of *Tetraclita* are slightly different from those found on the mainland of Tasmania in that they frequently have a furry epidermal covering to the shells. I have seen this only rarely on Tasmanian specimens. *Tetraclita purpurascens* is especially common under rocks between South Point and Lower Midden Rock. *Ibla quadrivalvis* is also semi-cryptic in habit and is most common under the stones at North Point. *Ibla* has a greater toleration for sun exposure than *Tetraclita* and is found in places experiencing more sun exposure than the situations favoured by the latter species. It is particularly interesting to note that there is no association with *Galeolaria* on sun exposed rocks such as is found in many places in Tasmania. However, this association does occur under boulders on Fisher Island.

The small lamellibranch, *Kellia australis* (Lam.) is common in Tasmania, usually living in large numbers below *Galeolaria* tube masses or suitable algal masses such as *Lithophyllum hpyerellum* (Foslie). However, on Fisher Island in the absence of *Galeolaria* masses and *Lithophyllum* this mollusc is found living in clusters at North Point, generally in the shelter of stones, but not in close association with other animals or plants.

NOTES ON THE ECOLOGY OF EDDYSTONE POINT

Eddystone Point furnishes a different type of habitat from that seen on Fisher Island, the wave action there is strong but there is a point of similarity in that the substratum at both localities is granite. This zonation at Eddystone is variable due to the broken nature of the shoreline offering different wave exposures but in general the following is the pattern which is followed:—

Littorina unifasciata
Chamaesipho columna
Siphonaria funiculata + *Siphonaria diemenensis*
Cellana solida
Corallina and/or *Lithophyllum*
Sarcophycus potatorum

This pattern is characterized by an absence of *Galeolaria caespitosa* as a belt-forming organism on exposed places, though this species may form dense clusters in clefts on sheltered localities. It occurs as scattered tubes over most of this area. Mussels (*Austromytilus erosus* and a few *Mytilus planulatus*) are found only in clefts or in sheltered positions.

The Midlittoral Belts

Lichina confinis forms a scattered belt in places below the *Littorina* belt at approximately the wave level of the *Siphonarias*. Like the latter species, the *Lichina* belt is sporadic in occurrence.

The salient feature of this belt was the relative scarcity of *Chthamalus antennatus*. This species does occur at Eddystone and is very common further to the west on the North Coast, e.g., West Head (Kershaw, 1957).

In places with broken water the lower part of the *Chamaesipho* belt is populated by *Catophragmus polymerus* Darwin, though this species is very local in distribution. The lower part of the *Chamaesipho* belt is often mixed with *Poneroplax albida* (Blainville) which may be considered to form a belt in places on the rocks. *Poneroplax* is often mixed with *Lithophyllum hyperellum* (Foslie). In the absence of *Lithophyllum* the lower part of the *Chamaesipho* belt contains *Cellana solida*.

Siphonaria funiculata (Reeve) is common on sun-sheltered or partially sheltered rocks in the upper half of the barnacle belt below *Littorina* and is usually associated with *S. diemenensis*.

The Infralittoral Fringe

Sarcophycus potatorum (Labill.) Kutz is the dominant alga of this part of the shore together with *Phyllospora comosa* (Labill.) J. Ag. The dominant alga in places with submaximal wave action is *Lessonia corrugata* Lucas and the species of *Cystophora* may become locally important in very sheltered gullies. It is noteworthy that the plants of *Sarcophycus* are not as large as on other exposed Tasmanian coasts. There are a few *Pyura* around the holdfasts of *Sarcophycus* but they are small in size.

DISCUSSION

This paper describes the zonation and general ecology of an area in the north of Tasmania. This area proves to be of considerable interest, the zonation being somewhat different from that seen on other parts of the Tasmanian coast. Kershaw (1957) described the ecology of an area at the Tamar Heads, also in North Tasmania and Fischer (1940) worked at Burnie. Kershaw's paper was primarily concerned with the mollusca and Fischer's observations were very brief and mentioned only the zone forming species.

The most obvious feature on the island is the very prominent and almost continuous *Cellana* belt. The belt is rarely continuous anywhere else that I have examined in Tasmania and *Cellana* certainly has never been found to be as conspicuous.

The principal points of interest on Fisher Island do not lie in the organisms forming belts on the shore but in the species which are encountered there and in the absence of certain species.

One species, represented by three individuals, which I was very surprised to encounter in the intertidal region was the urchin, *Goniocidaris tubaria* (Lam.). This species is very common on certain dredging grounds 5-10 fathoms in Southern Tasmania but I have never found it in the intertidal region in the south. *Amblypneustes ovum* (Lam.) is another urchin which is usually found below water in Southern Tasmania. The Vermetid species *Serpulorbis sipho*, common below stones at North Point, is another which I have never found between tidemarks in Tasmania.

The absence of limpets, such as species of *Conacmaea, Patelloida* and *Chiazacmea* which extends into Victoria or even New South Wales, are absent or rare on Fisher Island and from many of the surrounding islands of Franklin Sound. In December, 1956, I did not see any *Collisellina latistrigata* (Angas), though I recorded the species in 1954 when it was rare. Apart from *Cellana*, the only limpets collected are *Patellanax chapmani* (Ten.-Woods) *Patelloida alticostata* and *Notoacmaea scabrilata* (Angas) together with *Siphonaria diemenensis* (Quoy & Gaim.). The latter species is not common and the *Siphonaria "zonata"* form of this species is absent from the island. This is very surprising in view of the widespread distribution of this form in Tasmania.

The absence of anemones is another feature of Fisher Island. The red *Actinia tenebrosa* (Farq.) is found on the nearby Little Green Island and on rocks in Gunter's Bay on the mainland of Flinders Island, but is absent from Fisher Island, in spite of there being plenty of apparently suitable semi-cryptic habitats. The larger *Oulactis muscosa* (Drayton) is also absent from Fisher Island, though it is also absent from surrounding islands. The geographic range of this species is from Southern Tasmania to New South Wales so that we must look to reasons other than geographic distribution to explain the absence of this species from Fisher Island.

The crab fauna is poor in species but not in numbers. There are no Porcellanids below stones, which is very much the opposite of conditions on the Tasmanian mainland where *Petrolisthes elongatus* (M.Edw.) frequently occurs in thousands on shores similar to that on the North Point of Fisher Island. The Grapsid *Helice haswellianus* (Whitelegge) occurs at North-West Boat Harbour in large numbers, every stone sheltering one or more individuals. *Leptograpsus variegatus* (Fabr.) is common under rocks or in clefts on the upper part of the shore.

The long period covered by the three visits to Fisher Island has enabled me to make some observations on the long time changes which have taken place on the shore. Not only do the changes consist of minor alterations in the species present but the actual zonation on the island has altered. As I intend to discuss this topic fully elsewhere, it is sufficient to record the major changes that have taken place. The main change is the appearance of *Hormosira* as a belt forming species. In 1954 there was little *Hormosira* on the island, except at South Point where there were sporadic plants. At this time, the zonation there was barnacles, *Galeolaria, Galeolaria* + *Pyura*. *Hormosira* has colonized part of the shore around all of the island since 1954, probably to the detriment of the serpulids.

The barnacle population, as noted above, has become greater since 1954, probably due to the successful large spatfall noted in that year. However, this colonization was not achieved at the

expense of other species since, with the exception of South Point and some other very restricted areas, there is plenty of available space in the barnacle belt.

It is noteworthy that *Melanerita melanotragus* is much more common than on the east and west coasts of Tasmania where it is scarce to rare and is absent in the south. *Melanerita* is very common on the north coast of Tasmania at Kelso (Kershaw, 1957) and Burnie.

Fisher Island shows some important gradations between the zonation seen in Tasmania and that described for Victoria by Bennett and Pope (1953). It is important to note that Bennett and Pope were primarily concerned with exposed coasts and that the Eddystone Point area is also an exposed region so that Fisher Island is not ecologically under the same conditions as either of the other localities and true comparisons cannot be made. However, from descriptions of other sheltered localities in Tasmania it is possible to draw certain general conclusions regarding the ecological position of Fisher Island.

Bennett and Pope record that the chiton *Poneroplax albida* is a belt forming species in Southern Victoria. I have never regarded this species as being sufficiently numerous in Tasmania to warrant the status of a belt forming species being conferred upon it. However, at Eddystone Point this chiton is very much more common than in more southerly parts of Tasmania but it is apparently much smaller in size. It is not surprising that this species is absent from Fisher Island, since it is generally found on coasts experiencing at least moderate wave action. This latter remark applies equally well to the alga *Lithophyllum hyperellum* Foslie, which is very common at Eddystone Point. Although it occurs on the exposed parts of Babel Island, *Lithophyllum* is a species of southern exposed coasts, being not found in Victoria.

The continuity and importance of *Cellana* at Fisher Island, the associated islands of Franklin Sound and at Eddystone Point are features which are essentially Northern Tasmanian in affinities. This large limpet is widespread throughout Tasmania but nowhere in the south does it reach the importance attained at both Eddystone Point and Fisher Island. It is noteworthy that *Cellana solida*, although recorded from Victoria by Macpherson (1955) was not recorded by Bennett and Pope. Pope (1955) records it as absent from Victoria. The poverty of other species of limpets and *Siphonarias* both in species and numbers at Fisher Island is somewhat puzzling. A number of Patellids and Siphonarids occur both at Eddystone Point and in Victoria. Cape Barren Island supports a varied fauna of patellids as well as a large number of *Siphonaria diemenensis* (Quoy & Gaim.). The absence of these organisms from Fisher Island must be due to some local feature.

The position of *Cellana* relative to other zonal organisms is one of considerable interest. In Southern Tasmania at Blackman's Bay (Guiler, 1950) it was noted that *Cellana* occurred below the *Galeolaria* belt together with *Patelloida alticostata* and *Siphonaria diemenensis*. Under certain conditions *Cellana* was found above *Galeolaria*, particularly in regions with some splash from waves. This conclusion was in contrast to the conditions described in New South Wales by Dakin, Bennett & Pope (1948) where *Cellana* occurs above *Galeolaria*. It is worthy of note that *Cellana* has now become sparse in the Blackman's Bay area (Dudgeon in litt.). In general throughout Tasmania, there may be a Patelloid belt below *Galeolaria* but the characteristic habitat of *Cellana* is above *Galeolaria* on less than semi-exposed coasts. *Cellana* does occur on exposed coasts, e.g., Eaglehawk Neck where it occurs in a mixed Patelloid belt above the Corallines. This level is probably equivalent to below *Galeolaria* but it is difficult to compare these levels with accuracy since *Galeolaria* does not form belts on exposed coasts.

The barnacles of Fisher Island reflect the typical north coast feature of many more *Chthamalus antennatus* in the upper part of the barnacle belt. This feature has been noted elsewhere as occurring at Boat Harbour (Guiler, 1952), Kelso (Kershaw, loc. cit.) and it is also to be seen on Cape Barren Island and at Eddystone Point.

In conclusion, it can be said that the intertidal zones on Fisher Island and Eddystone Point, apparently in common with certain other localities in Northern Tasmania, show greater affinities with Victoria than with Southern Tasmania. In particular, the presence in the intertidal region of some species which are found in the Infralittoral in the south, e.g., *Serpulorbis sipho* and *Goniocidaris tubaria* together with an apparent reduction in the size of cold water loving species such as *Sarcophycus* and *Poneroplax albida*, points to a slight warming of the cool water. However, at this stage, it cannot be assumed that this warming is sufficient to warrant the removal of the seas of Northern Tasmania from the cool temperate Maugean province to which they have been assigned. Certain species found at Fisher Island, such as *Chthamalus antennatus*, *Melanerita melanotragus* and *Patellanax chapmani*, are common in Victoria and Eddystone Point but are absent or scarce in Southern Tasmania. *Melanerita* is fairly numerous at Coles Bay but is rare at Eaglehawk Neck in south-eastern Tasmania. All of the dominant species are cold temperate in affinities but the warm temperate element is very much stronger at Flinders Island than in Southern Tasmania.

FAUNAL LIST

The list of the more common animal species found between the tidemarks on Fisher Island is set out below. This list is based upon my own observations and upon a reference collection of Mollusca made by E. H. Sedgwick in February, 1954, and identified by Miss J. Hope Macpherson. It should be stressed that this list is by no means complete and must serve as a beginning for further collections.

	Habitat.	Status.	Author
PORIFERA			
Hymeniacidon perlevis (Montagu)	Below stones, N. Pt.	Frequent	E. R. Guiler
Large grey species	S. Pt.	Frequent	E. R. Guiler
TURBELLARIA			
Leptoplana australis (Laidlaw)	Below stone, N. Pt.	Frequent	E. R. Guiler
ANNELIDA			
Galeolaria caespitosa (Lam.)	Ubiquitous, Midlittoral	V. common	E. R. Guiler
CRUSTACEA			
Ibla quadrivalvis (Cuvier)	Amongst mussels, N. Pt.	Common	E. R. Guiler
Tetraclita purpurascens (Wood)	Semi-Cryptic	Common	E. R. Guiler
Chthamalus antennatus (Darwin)	Barnacle belt	V. common	E. R. Guiler
Chamaesipho columna (Spengler)	Barnacle belt	V. common	E. R. Guiler
Halicarcinus planatus (Fabr.)	Amongst mussels, N. & S. Pt.	Frequent	E. R. Guiler
Nectocarcinus integrifrons (Lat.)	Frequently found dead on shore		E. R. Guiler
Leptograpsus variegatus (Fabr.)	Under rocks, Supralittoral Fringe	Common	E. R. Guiler
Helice haswellianus (Whitelegge)	Under rocks, Midlittoral, N. Pt.	Common	E. R. Guiler
MOLLUSCA			
Sypharochiton maugeanus (Ired. & May)	Semi-cryptic clefts, ubiquitous	Common	E. H. S. & E. R. G.
Cryptoplax striata (Lam.)	N. Pt.	Scarce	E. H. S. & E. R. G.
iredalei (Ashby.)	N.E. Boat Harbour	Scarce	E. R. Guiler
Ischnochiton elongatus (Blainville)	N. Pt. cryptic	Scarce	E. R. Guiler
Aulacochiton cimolia (Reeve)			E. R. Guiler
Acanthochiton sueurii (Blainville)	N. Pt., below stones	Scarce	E. R. Guiler
Arca pitsachia (Lam.)	N. Pt., amongst stones	Frequent	E. R. G. & E. H. S.
Ostrea sinuata (Lam.) = *angasi* (Thompson, 1954)			E. H. S.
Equichlamys bifrons (Lam.)	Doubtful if intertidal		E. H. S.
Austromytilus erosus (Lam.)	N. & S. Points	Common	E. H. S. & E. R. G.
Modiolus pulex (Lam.)	N. Point	Common	E. R. G.
Kellia australis (Lam.)	N. Point	V. common	E. R. G.
Venerupsis exotica (Lam.)	N. Point	Scarce	E. R. G.
Katelysia sp. juv.	?	?	E. H. S.
Pseudarcopagia victoriae (Gat. & Gab.)	?	?	E. H. S.
Notohaliotis ruber (Leach)	I. L. Fringe	Frequent	E. H. S.
Neohaliotis emmae (Reeve)	I. L. Fringe	Frequent	E. H. S.
Schismotis laevigata (Donovan)	I. L. Fringe	?	E. H. S.
Scutus antipodes (Montford)	Midlitt. Fringe	?	E. H. S.
Cellana solida (Blainville)	Midlitt. Fringe	V. common	E. H. S. & E. R. G.
Patellanax chapmani (Ten.-woods)	Midlitt. and N. West Boat Harbour	Frequent	E. R. G.
Patelloida alticostata (Angas)	Midlitt., general	Common	E. R. G.
Notoacmea scabrilirata (Angas)	N. Point	Scarce	E. R. G.
Clanculus undatus (Lam.)	N. Point	Common	E. H. S. & E. R. G.
Clanculus plebejus (Philippi)	?	?	E. H. S.
Phasianotrochus bellulus (Dunker)	?	?	E. H. S.
Thalotia conica (Gray)	?	?	E. H. S.
Austrocochlea concamerata (Wood)	N. & E. Coasts	Common	E. H. S. & E. R. G.
Austrocochlea obtusa (Dillwyn)	Generally distr.	Common	E. H. S. & E. R. G.
Stomatella imbricata (Lam.)	?	?	E. H. S.
Herpetopoma baccata (Menke)	?	?	E. H. S.
Gena impirtusa (Burrow)	?	?	E. H. S.
Micrastrea aurea (Jonas)	Below mussels, N. & S. Pts.	Common	E. H. S. & E. R. G.
Phasianella australis (Gmelin)	?	?	E. H. S.
Melanerita melanotragus (Smith)	N. & E. Coasts	V. common	E. H. S. & E. R. G.
Bembicium imbricatus (Gray)	?	V. common	E. H. S.
Bembicium auratum (Quoy & Gaim.)	Ubiquitous	V. common	E. R. G.
Littorina unifasciata (Gray)	Ubiquitous	V. common	E. R. G.
Serpulorbis sipho (Lam.)	S. & N. & E. Coasts	Scarce	E. R. G.

	Habitat.	Status.	Author
Zeacumantus diemenensis (Quoy & Gaim.)	N. Coast below stones	Frequent	E. R. G.
Ianthina smithiae (Reeve)	?	?	E. H. S.
Sabia conica (Schumacher)	N. Point	Rare	E. R. G.
Notocypraea verconis (Cotten & Godfrey)	?	?	E. H. S.
Negyrina subdistorta (Lam.)	?	?	E. H. S.
Cymatiella verrucosa (Reeve)	N. Pt.	Scarce	E. R. G.
Pterynotis triformis (Reeve)	?	?	
Lepsithais vinosa (Lam.)	Below mussels, N. Pt. & S. Pt.	Common	E. R. G.
Dicathais textiliosa (Lam.)	?	?	E. H. S.
Zemitrella acuminata (Reeve)	N. Pt.	Frequent	E. R. G.
Cominella lineolata (Lam.)	N. & S. Pt.	Common	E. H. S. & E. R. G.
Fax tenuicostata (Ten.-Woods)	N. Pt.	Rare	E. R. G.
Austrosipho grandis (Gray)	?	?	E. H. S.
Parcanassa pauperata (Lam.)	?	?	E. H. S.
Pleuroploca australasia (Perry)	S. Pt.	Scarce	E. R. G. & E. H. S.
Mitra sp. juv. (?*rhoda*)	N. Pt.	Scarce	E. R. G.
Amorena undulata (Lam.)	S. Pt.	Rare	E. R. G. & E. H. S.
Austrodrillia beraudiana (Crosse)	N. Pt.	Scarce	E. H. S. & E. R. G.
Floraconus anemone (Lam.)	S. Pt.	Rare	E. R. G.
Salinator sp.			
Siphonaria diemenensis (Quoy & Gaim.)	W. & N. Coasts	Scarce	E. R. G.
Decorisepia rex (Iredale)			E. H. S.
Crumenasepia ursulae (Cotton)			E. H. S.
ECHINODERMATA			
Patiriella exigua (Lam.)	Slipway	Frequent	E. R. G.
Amblypneustes ovum (Lam.)	N.E. Boat Harbour	Several	E. R. G.
Goniocidaris tubaria (Lam.)	N.E. Boat Harbour	Several	E. R. G.
UROCHORDATA			
Pyura stolonifera (Heller)	S. Pt.	Common	E. R. G.

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FIG. 1.—South point Fisher Island, showing the top of the barnacle zone with *Lichina*.

PLATE I

FIG. 2.—Mussels at the slip-way, North Point.

FIG. 1 —The *Bembicium* and *Cellana* belts on the east shore, Fisher Island.

PLATE II

FIG. 2.—South Point looking north. *Pyura* in right foreground, *Galeolaria* and *Bostrichia* above.

SOME NOTES ON HORTON COLLEGE, ONCE, A WELL-KNOWN SCHOOL NEAR ROSS, TASMANIA

By

E. R. Pretyman, Hobart

Perhaps one of the most ambitious ventures ever contemplated for the Midlands of Tasmania, was the suggested opening of a College and Boarding-School for Boys near the township of Ross.

One hundred and ten years or a little more have now gone by since consideration was, we believe, being given at "Somercotes", the home of the late Captain Samuel Horton, to the establishment of a Wesleyan Methodist College for Boys in Tasmania.

"Somercotes", still occupied by relatives of the Captain, stands about two and a half miles south of Ross, on the Main Road from Launceston to Hobart, but the old College building has long since been demolished.

During its useful years Horton College was the home of a great succession of boys, many of whom became Tasmania's most successful doctors and barristers, best known clerymen, most enterprising merchants, and many others who filled with credit to themselves and their school the vocations they afterwards followed.

But before giving details of the actual founding of the school and a little of its history, some reference, perhaps, should be made to events which led to an area of 20 acres near Ross being reserved for this particular school.

Settlement in our Island began in 1803. In September of that year Lieutenant Bowen landed with his party at Risdon on the River Derwent. A few months later (November, 1804) quite independently of the southern attempt, the British flag was hoisted at Outer Cove on the northern coast of Van Diemen's Land, as Tasmania was then known, but both settlements were moved later to more suitable surroundings. Communication between them, if any in those early days, was made only by way of the sea.

Statistical reports go to show that there was a serious shortage of food in the Island during 1807. Partly because of the extreme conditions in Launceston, or Port Dalrymple as it was first called, it was deemed necessary to seek relief and so a small party under the command of Lieutenant Laycock set out for Hobart Town by way of the then unknown bush. The journey, a comparatively short one these days, took them eight days to complete. Once a way through was discovered it was not long before other people began to move to and fro along the route.

By 1811 this route, believed to have been about 160 miles long, must have been fairly well defined, for Governor Lachlan Macquarie who made a visit to this Island then, recorded in his Journal that he made a trip through the country by means of "the track for travellers". He at the same time referred to his intention to establish four military posts "to keep open the means of communication between the two settlements and to furnish protection to such persons as may wish to settle in the interior".

Macquarie, who was Governor of New South Wales as well as Governor in Chief of Van Diemen's Land, again visited this Island in 1821, and on the journey from north to south chose sites for towns and gave them names. The site to which I particularly wish to refer he called "Ross".

One of the earliest grants in or near Ross was made by Sir Thomas Brisbane to Charles and Henrietta Bowen. Among other grants made later by Sir Thomas was one of 1000 acres or thereabouts to Samuel Horton.

By 1826, Ross had become the centre of settlement in the midlands. "The Union Agricultural Society" of the district considered itself sufficiently important and asked the Lieutenant-Governor, Colonel George Arthur, to become its Patron. The 1827 Almanac refers to a fine show of thoroughbred horses at the Ross Market. This market was held every three months and there is evidence to show that it was operating earlier than 1826. The district was considered to be admirably adapted for the growth of fine wool and the Almanac for 1829 adds that "Ross stands in the centre of some particularly rich and fertile plains of some considerable extent" and "to the right of Ross are extensive tracts containing 30,000 acres of the best land in the Island". Can we wonder that later this locality was deemed suitable for the site of "Horton College".

Just before Macquarie's second visit to Van Diemen's Land, the Rev. Benjamin Carvosso visited Hobart Town on his way to New South Wales. The date recorded in his Journal is 25th April, 1820. He was so impressed with the need for guidance in spiritual matters for the population of Hobart Town that he wrote and made feeling representation to the Missionary Committee in London asking for a missionary for them. He preached the first sermon from the Wesleyan point of view to those residents of the town who would listen. Another Wesleyan Missionary, the Rev. Ralph Mansfield also preached shortly afterwards on his way through to Sydney.

The efforts of these two men led a few converted soldiers to form the nucleus of a Methodist Society. In spite of persecution their numbers increased to 34 and a Sunday School was established. So in August, 1821, when other Wesleyan Missionaries, the Revs. Leigh, Walker and William Horton arrived at Hobart Town on their way to New South

Wales it was agreed between them that Mr. and Mrs. Horton should, pending the receipt of the necessary authority, remain and take charge of the infant church.

It seems that William Horton was so impressed with the prospects and possibilities of Van Diemen's Land that he wrote to his cousin Captain Samuel Horton and persuaded him to come to the Colony. Samuel Horton reached Hobart Town in 1823 and immediately set about going through the formalities of obtaining a grant of land near to the midland centre of Ross.

British Army Regulations at that time permitted officers, not under the rank of captain, to sell their commissions and emigrate to Van Diemen's Land where they would be sure of land grants on arrival. Other immigrants were granted land in proportion to the capital they brought in. Each settler had to go to the Surveyor's Office and demonstrate the amount he had brought to the Colony and quote and describe the number of livestock, farm implements and seed he had. To encourage milling, a special grant of 500 acres was made to settlers who were prepared to erect and work flour mills on their properties.

Land surveying at that time, even allowing for the great difficulties existing, was incredibly careless. Surveyors apparently did little more than count the turns of their conveyance's wheel or their horses' footsteps when measuring distances between pegs.

Samuel Horton was a sea-captain in the Merchant Service which traded in the China Sea before he came to Van Diemen's Land, but apparently gave up that calling to come and settle on the land. After receiving the necessary authority or permit from the Surveyor's Office he journeyed with Thomas Parramore to the property which soon became his home near Ross. It took them 10 days to reach and locate the area received by the Captain under a grant dated 30th June, 1823. He called his property "Somercotes" and in so doing brought the name of the district in which his family lived in Lincolnshire, England, to this side of the world.

Nearly 10 years later the marriage of Samuel Horton to Miss Elizabeth Pridden Hudson took place in the little church at Jericho. The Rev. James Norman conducted the service on 26th April, 1833. Thomas Parramore signed, together with William and Emma Pike, as a witness to the ceremony.

About this time Governor Arthur attempted to revive a project for establishing a College for the secondary education of the youth of the Colony. Much discussion took place but it seems that nothing concrete was done and sectarian difficulties made their appearance. Governor Arthur was withdrawn in 1836. Sir John Franklin took his place and two years later again took up the subject of the establishment of a College in the Colony. According to the Hobart Town *Gazette* of 1840 he is reported to have said, "The leading object, however, now in contemplation, is to found a superior school on such a system that it may at a future period become a College, and be a means of affording a liberal education to the sons of Colonists, and of preparing them for entering upon the study of the Learned Professions."

Dr. Arnold of Rugby, from whom Sir John had sought advice, wrote (in 1841) "In all British Colonies it is manifest that the Scotch Church has equal rights with the English, and the Roman Catholic has equal rights morally, yet to instruct independently of any church is monstrous and to teach for all three churches together is impossible. I can only conceive the plan of three distinct branches of one college."

Again in 1842 Dr. Arnold wote, "Mixed Institutions are to my mind so undesirable that I would rather have a college Scotch altogether than that it should represent no church at all."

Franklin's plan appears to have been to have the Government control secondary education, much in the same way as the Government now controls the State High Schools, but the rivalry of the various churches prevented his ideas being carried out. The claims of Bishop Nixon that Franklin's suggested college should be placed under the responsibility of the Church of England, —"the Established Church"— was warmly resented by members of the Presbyterian Church and the "Dissenters" as members of other denominations were called, and brought about much bitter controversy.

Education and kindred subjects no doubt must have been freely discussed during Ministerial visits to "Somercotes". From the conclusions reached, there does not appear to be any doubt that Samuel Horton had suggested the way and offered the means whereby sons of Wesleyans might be independently educated, and according to Wesleyan ideals.

So from the Minutes of the Wesleyan District Meeting held on 17th July, 1850, we learn that the Chairman and Secretary were requested to place the "Somercotes" suggestion fully before the London Committee and to "solicit their countenance and pecuniary aid". By the time the District Meeting met in July, 1851, it had been decided definitely to go on with the scheme for establishing a Wesleyan College in Tasmania. Meetings were held throughout the circuits of the Colony "to excite an interest and to gain financial assistance". The Chairman was requested to get the Deed conveying the property "drawn up without delay".

According to a publication called "The Watchman" of 7th July, 1852, "The foundation stone was laid at noon on 6th January, 1852 in the presence of people of all classes and every Wesleyan minister in the Colony. A Parchment Scroll was placed in a cavity under the Foundation Stone and bore the words, 'This Stone was laid in the name of the Holy Trinity on Tuesday the 6th day of January, in the year of our Lord 1852 and in the 15th year of the reign of Her Gracious Majesty Victoria, Queen of the United Kingdom of Great Britain and Ireland, and in the 5th year of the administration of Sir William Denison, Lieutenant Governor of Van Diemen's Land by SAMUEL HORTON Esquire, the generous founder of this College, in commemoration of whose munificence the building is to be designated "HORTON COLLEGE". "The Property has been conveyed in trust to the Wesleyan Church for its sole use and benefit as a collegiate

institution for ever'." "Over two hundred of the company then enjoyed 'an excellent repast prepared by Mrs. Horton.'"

During 1851 and 1852 gold was being discovered in Victoria and it was not long before thousands of able-bodied men were seeking their fortunes in that Colony. In consequence the price of manual labour and building materials in Tasmania rose enormously and fears began to be entertained that the building of the College would be delayed indefinitely. Some folk contended that such an establishment as the College was "not necessary" or that "it was much before its time", others, were sure that it would be of great benefit for many years to come and they won the day. Construction of the building proceeded slowly. It was not till the end of 1855 that the structure neared completion, even then only the central portion and one wing, the northern one, had been erected.

The College stood opposite "Somercotes" about two miles south of Ross, on the Main Road between Hobart and Launceston. It was a brick building of two storeys with "dressings and trimmings of carved freestone" set back a little from the road in a block of five acres. This area was later set out in lawns with shrubs and flower beds, many of the plants being supplied from the Royal Society's gardens in Hobart; and to quote Dr. Jobson, who was sent out as the representative of Methodism in England to the Methodist Conference at Sydney in 1861 "The College was backed by round moulded hills and surrounded by arable and pasture land". The bricks for the building were made nearby by convicts and the press with which they were shaped could, until recently, be seen at "Somercotes". Stone was taken from the famous quarries near Ross.

The Rev. J. A. Manton was appointed President or Governor of the College, but it was not till September, 1855, that the building was ready for occupation. Mr. Manton's son John was the first scholar enrolled under the date 3rd October, 1855.

Qualification for admission to the College was "an ability to read the New Testament with facility", and had been laid down by the District Meeting of 1852. By the end of 1855 seven students were attending.

The earliest known advertisement relating to the College is one held by the Mitchell Library, Sydney. It refers to the proposed erection of the building and was probably the circular sent out to Methodist Circuits in 1851, It is undated but bears the names of H. H. Gaud and J. A. Manton. Another reference to the College appears in the Hobart Town Directory for 1857 under the heading "Ecclesiastical—Wesleyan Church, Campbell Town and Ross, Rev. J. A. Manton, President Australasian Conference and Governor, Horton College".

Further reference to Horton College, Ross, is made in Walch's Tasmanian Almanac for 1863, the first year of its publication and reads:—

> "The College is the result of contributions by friends of education in Tasmania. Captain Horton of "Somercotes", Ross, having commenced the enterprise by a gift of twenty acres of land as a site for the college and a contribution of £1,000.
>
> "The object contemplated is to afford to sons of Protestant Christians the advantage of a sound general education in connection with a christian home and careful moral and religious training.
>
> "In October 1855 under the presidency of the Rev. J. A. Manton the first pupils were received. Since that period the average number of students has been about fifty: up to the present time 168 have been entered on the College books. The entire cost of the building and furnishings was about £4,500.
>
> "The examinations which have been conducted during the last two years, under the "Tasmanian Council of Education and Scholarship's Act" have given to Horton College a first position among the schools of the Colony, and enabled it to enrol five Associates of Arts.
>
> "The trustees are now enlarging the College, by adding a new wing and thus completing the edifice, the estimated cost of which is £2,000.
>
> "President of the College, Rev. W. A. Quick; Head Master, S. Fiddian; Second Master, J. W. Catton; Third Master, E. W. Nye.".

The Almanac for 1864 records that W. W. Fox was the Head Master. Actually he was appointed in England and received instructions to take up duties at the College from the beginning of 1863. Before he reached the College in February, a start had been made on the new wing made necessary by the steady increase in the demand for enrolment. 1862 ended with 66 boys attending the school.

It was November, 1863, before the new or south wing could be occupied. This addition allowed a partition wall in the old building to be removed and a larger dining hall provided, it also pracically doubled the accommodation, increasing the number of rooms for staff, classrooms, &c., to 38. The alterations cost £2,000 and largely due to the untiring efforts and careful supervision of Mr. Quick who had received many donations from friends of the College this sum was paid over immediately on completion.

The central block consisted of the main school hall, the dining-hall and classrooms on the ground floor, and on the first floor were two large dormitories, one of them 70 feet by 30 feet, known as the "Chapel" and the other as "number thirteen". The north wing contained the President's quarters, the kitchen, the matron's room (known to the boys as "Number Six") and some of the smaller bedrooms. The southern wing was used for the residence of the Head Master, Staff-room and more class and bedrooms.

From the day of his arrival to the time he retired, Mr. Fox the Head Master worked extremely hard at Horton College to maintain traditions of old English schools, on which under freer Australian conditions Horton College was fashioned.

On 10th November, 1867, Captain Samuel Horton died at the age of 71 years. During his lifetime he had had a vault prepared on a rocky hill overlooking the College and "Somercotes" and to this resting place his remains were then taken. He had no children and his estate was left to his widow with the provision that unless she chose otherwise it was to pass to Thomas Riggall, the

nephew who had come from England to manage it for him. He had further provided that should his nephew leave no children to reach the age of 21 years, the property was to be divided into five parts. Two parts were to go to the British and Foreign Bible Society in England, two parts were to go to the Wesleyan Mission in Sydney for use in Pacific Island Missions and the remaining part was to provide the income for a Scholarship at Horton College. Later many people regretted that he had not fully endowed the College.

To indicate the type of man the hard working Captain was, one story is mentioned. It seems that during 1843 Martin Cash, the noted bushranger, afterwards pardoned, made a visit to "Somercotes", took the inmates completely by surprise and finally bailed up the Captain when he rushed to see what was causing a commotion in the place. It is not hard to imagine the scene described. "Somercotes" men were lying bound on the floor of the kitchen and the Captain, standing with his back to the fireplace, was saying "You may shoot me Cash, but God will protect me. I am not afraid to die, but you are". Bullet marks on the doorway of one of the rooms at "Somercotes" believed to have been caused by a shot from an outlaw's pistol were always an object of awed interest to the boys of the College who were fortunate enough to go and see them.

For some time after the Captain's death, and possibly due to a minor depression in Tasmania, admissions to the College fell considerably, but when it was found that the school was to continue and that conditions generally were improving a period of great prosperity followed. Many improvements were made to the school property. A very fine new tower was added to the central portion of the building, the shingle roof was replaced with iron and an iron gymnasium and large playshed built. The Council of the College made a donation of £200 towards building a new Wesleyan Church at Ross, and the sum of £1,000 was advanced on loan to the Methodist Ladies' College in Launceston. And such was the prosperity at that time that the 1884 Balance Sheet showed a Reserve Fund of £853, a Manton Exhibition Fund of £533 and a Horton Scholarship Fund of £469.

The motto of the College for many years was "Nil sine magno labore", this was later replaced by "Perseverantia Palman Obtinebit". The origin of the College badge or crest is not known.

It is probable that only two boys left their impressions of the school in print, and one of these wrote, "Life at the school was free and pleasant. Sunday was a welcome day, as it is in such institutions all over the world. The time of rising was 7 a.m. instead of 6.30 and after washing at a long row of basins arranged along the length of the dormitory, and putting on clothes and slippers, for boots were never allowed in the dormitory, the boys took their places at their desks in the schoolroom as on other days, and when 8 o'clock struck they were marched into the dining hall where the President joined them and conducted prayers. Breakfast followed and then an hour later, three or four abreast, they walked the 2½ miles to Ross for service in the little Wesleyan Methodist Church there". "On week days the boys were, on suitable mornings, taken out for drill and short bursts of "double quick" on the Main Road. Periodical visits of a chaise cart loaded with 6d. packets of sweets, &c., provided the College 'tuck-shop'. Once at a standstill, horse, cart and salesman used to be very nearly smothered by eager customers".

Bathing, boating and fishing were popular pastimes on the Macquarie River. On hot afternoons the boys were allowed to leave school early, at three o'clock instead of four, to go swimming. On spare afternoons "al fresco" meals of chipped potatoes, with a rabbit boiled in a billy-can and damper made on stone were events of high delight for some. Of course there were cricket and football matches, paper chases over neighbouring properties and other games in season. For those boys wishing for something more strenuous to do there was always wood from the hugh pile to be cut. Property owners round about permitted the College pupils to roam at will. There were many favourite resorts and many a fine collection of wild bird eggs was made during the nesting season.

Indoors there were the usual midnight suppers, pillow fights and so on, and each spring a bird-keeping craze always swept the school. Boxes of all shapes and sizes lined the walls of the large shed in the playground, containing young magpies, jackasses, parrots, crows, hawks and other birds.

According to an advertisment in Walch's "Literary Intelligencer" of March, 1864, parents were required to pay per annum "For Board & Education, £50", "Washing, £4 4 0", "Medical attendance £1 1 0" and to provide two pairs of sheets, three pillow cases, six towels and a silver fork and spoon, all marked. Other articles were added to this list in later advertisements.

Vacations were two, six weeks at Mid-summer and a month in Mid-winter.

And then in 1889, just when the College seemed set for a long term of usefulness and service to the community, Mr. Fox, the able and popular Headmaster had to retire owing to ill-health. For 26 years he had not spared himself in the interest of the College and of the boys. The splendid scholastic achievements, moral and physical training were largely due to his firm and friendly guiding authority. The School Prospectus for 1888 gives some indication of the successful work of the boys. Between 1879 and 1887 they had obtained four Tasmanian Scholarships, 15 Associates of Arts degrees, three Dry Scholarships and numerous gold medals and other prizes.

(A "Tasmanian Scholarship" was valued at £200 per annum and was tenable for four years at some University in the United Kingdom. Two scholarships only were granted in each year by the State under the "Tasmanian Council of Education and Scholarship's Act" to those students who had been successful in obtaining an Associate of Arts degree.)

Troubles as a rule, it is said, do not come singly and so it was for Horton College. Almost immediatly following Mr. Fox's resigning a "Depression" of some magnitude struck the State of Tasmania and despite the fact that Mr. Fox had said the College was "in flourishing circumstances" the years were critical and conditions changing. Even though scholars at Horton College were said

to enjoy special advantages, one in particular, that they were altogether removed from the distractions of town life and thus enabled to give undivided attention to their studies, there seems to have been a growing tendency for parents to send their boys to schools nearer the centres of population.

So with a feeling of great regret we learn that by 1892 the school was in a hopeless financial position. All special funds had been used to meet current expenses and there still remained a debt of fifty-two pounds.

Various suggestions were made to the Wesleyan Methodist Conference, but apparently under the circumstances then existing it was considered doubtful whether anyone could put the College on a further successful career so long as it remained at Ross. Rather than close up the building immediately an agreement was entered into with a Mr. Steer to carry on his private school for boys there. The master's educational status was assumed however, and within a year the financial position had become worse.

The College Trustees were now embarassed with a building which they owned but which was built on land given in trust for collegiate purposes. All funds at their disposal were exhausted, so because of an uncertain legal position they decided to transfer quietly and as soon as possible the property back to the Horton Estate on the understanding that Mr. Riggall, Captain Horton's nephew and Trustee would pay all legal and outstanding expenses, which by then had grown to £250. And this was done despite the fact that Methodists throughout Australia had contributed over £5,000 towards the cost of the College buildings.

The residential portion of the school was then occupied for some time by Mr. Riggall's son, who on his father's death in 1917 decided to pull the building down and sell the material. Some of this went into building "Horton" a small homestead at the rear of the College. The College Bell came to Hobart and is now rung daily during term at Hutchins School. Some bricks were taken to Launceston and in 1935 built into one of the walls close to the foundation stone of the Mary Fox wing of the Methodist Ladies' College in Elphin Road, because of the associations of the two schools in the early eighties of last century. And so, with the exception of the building's entrance archway, which still stands, disappeared the visible remains of in it's day, one of the best known and most popular Methodist educational establishments in Australia.

In all some 770 boys passed through the College, most of them from Tasmania, but numbers from Victoria, New South Wales and even as far afield as New Zealand, and few of them there would be who did not all their lives remember the influence of Horton College which even today still reaches out to their descendants.

A NOTE ON TASMANIAN ABORIGINAL DRAWINGS

By

S. de Teliga and W. Bryden

(With 1 Plate)

Relatively little has been recorded of the Art of the Tasmanian Aborigines. The last of this race disappeared from the scene in 1876 but from the time of white settlement in the State until that date a number of rock carvings and drawings were found, many of them as a result of collaboration with the natives.

In 1802 Péron gave an account of drawings—possibly one of the first recorded accounts. The drawings he described were on bark and showed ". . . characters crudely marked, similar to those which the aborigines tattoed on their forearms".

Bunce in 1857 described drawings performed by aborigines in the Surrey Hills district of Tasmania—drawings on bark depicting carts drawn by oxen with drivers nearby.

Bonwick mentioned "the red hands marked on trees and rocks alike in Tasmania and Australia". Other reports have also been made but there has been little evidence of drawings on a large scale. Calder, Hellyer, Ling Roth, Meston and Ross have all made contributions.

Some months ago we received a report that in a cave on the banks of the River Derwent there were signs of aboriginal drawings. Our investigations showed that in the sandstone cave there were a few rough outlines, but what they were supposed to represent we could not determine. There were however a number of impressions or drawings of hands, both right and left. Red ochre had been smeared across some of the sandstone and the hand traced or drawn by using what appeared to us to be marl or limestone. It was difficult to get good photographs—neither was there enough natural light to get good definition nor would a flashlight show the details we would like to show. The accompanying plate shows the outline of a hand; in the cave a number of these were evident as were some other markings and drawings.

The locality was on the River Derwent about six miles from Ellendale, which is approximately 45 miles north-west of Hobart.

We are grateful to Mr. E. Bannister the owner of the property on which these caves are situated for the invitation to visit the caves and for his hospitality during our visit.

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OF

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The Royal Society of Tasmania

Volume 93

LIST OF OFFICE BEARERS, 1958

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Her Majesty the Queen.

President:

His Excellency the Governor of Tasmania (Rt. Hon. Sir Ronald Cross)

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Mr. G. E. A. Hale, B.Sc.

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Standing Committee:

Dr. E. R. Guiler, Mr. L. W. Miller, Mr. G. H. Stancombe and Dr. W. Bryden.

Royal Society of Tasmania

Papers and Proceedings Volume 93

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Royal Society of Tasmania.

Annual Report for the Year 1958.

President.

During the year the President of the Society, His Excellency Sir Ronald Cross, completed his term as Governor of Tasmania and returned to Britain. The Society expressed thanks to Sir Ronald for his interest and support, and opportunity was taken to express thanks to him in person before he left Tasmania.

Annual Meeting.

The Annual General Meeting of the Society was held on 5th March, 1958, when the President of the Society, His Excellency Sir Ronald Cross, occupied the Chair.

The following office-bearers were elected:—

Vice-President: Under the Society's Rules, Dr. W. E. L. H. Crowther retired from the office of Vice-President and Mr. L. W. Miller was elected to the vacancy.
Hon. Secretary and Librarian: Dr. W. Bryden.
Hon. Treasurer: Mr. G. E. A. Hale.
Hon. Auditor: Mr. A. M. Hewer.
Council: Under Rule 21 Dr. Martin and Dr. Teniswood retired from the Council and Dr. E. R. Guiler and Mr. K. D. Nicolls were elected in their places for a period of three years.

Professor Hytten resigned in December, 1957, and Dr. W. E. L. H. Crowther was elected to fill this casual vacancy for one year.

After the general business of the meeting was completed Professor J. McManners delivered a lecture on "Ceremony and belief in provincial France on the eve of the Revolution."

Committees.

The Council made the following appointments for the year:—

Standing Committee: Mr. L. W. Miller, Mr. G. H. Stancombe (Northern Branch), Dr. E. R. Guiler, Dr. W. Bryden (Honorary Secretary).
Representatives on the Trustees of the Tasmanian Museum and Art Gallery: Professor A. Burn and Mr. G. F. Davies.
Representative on the Trustees of the Botanical Gardens: In March Mr. S. Angel intimated that he would like to be relieved of the appointment and in September Mr. Guy Barrett was appointed in his place.
Representative to the Library Association of Tasmania: Dr. W. Bryden.
Representative on the Nomenclature Board: Mr. E. R. Pretyman.

Mr. S. Angel—Honorary Membership.

Council expressed their thanks to Mr. Angel who had represented the Society on the Board of Trustees of the Botanical Gardens for many years. He had also been a Council member for over 20 years, and Treasurer for about 19 years, and in November Council agreed to submit his name for nomination to Honourary Membership.

Clive Lord Memorial Lecture.

Mr. P. G. Law, Director of the Australian Antarctic Division, Department of External Affairs, was invited to deliver the Clive Lord Memorial Lecture. This was given at the October meeting which was held in the Town Hall, Hobart.

His Excellency, the Administrator (Sir Stanley Burbury) presented the Clive Lord Memorial Medal after which Mr. Law delivered the lecture which was entitled "Current Australian Scientific Research in Antarctica."

General Meetings.

Other meetings held were:—

April: "The Heart of the City" (illustrated), by Professor Peter Scott.
May: "What's in a Name" by Professor J. R. Elliott.
June: 'Darwin's Century" by Professor H. N. Barber.
July: "Water Resources in Tasmania" by Mr. A. W. Knight.
August: "The History and Significance of the Petroleum Industry in the Middle East" by Mr. N. R. Seddon, Managing Director of BP Australia Ltd.
September: "From Sea Waves to Electric Waves" by Professor Gordon Newstead.
November: Three films—"Wheels across Africa" "Address Antarctica" "As Old as the Hills."

Library.

Some 395 volumes (books and journals) were added to the library during the year. There are now 310 institutions on the exchange list and the number of volumes in the library has grown to 31,735.

Papers and Proceedings.

Volume 92 of the "Papers and Proceedings" was published and once again the Society wishes to extend thanks to the Government of Tasmania for financial support in this connection.

Assistant Librarian.

The Council is indebted to Miss E. M. Geddes for her services to the Society.

Thanks.

The Council extends its thanks to all those who have assisted by donations and by their interest and support.

Northern Branch.

In November a number of members from the Northern Branch came to Hobart. On the afternoon of Saturday, 29th November, Battery Point and

the Van Diemen's Land Memorial Museum were visited. In the evening films were shown and supper was served, and during this time members from both the North and South were able to meet and discuss matters of mutual interest.

On the morning of Sunday, 30th November, a number of treasures of the Royal Society Library were exhibited.

Council felt the visit was of great value and it is hoped that a similar visit to the North by Southern members may be arranged in 1959.

Royal Society Room.

During the year the room was painted and a start was made to rearrange the library. The Council wishes to thank members of the staff of the Tasmanian Museum for their help in this work.

Statement of Receipts and Payments for year to 31st December, 1958.

Receipts.

	£	s.	d.	£	s.	d.
Balance brought forward from 1957				33	15	11
Bank interest				9	10	0
Subscriptions:—						
1958. 263 @ £2 10s.	£657	10	0			
181 @ £2	362	0	0			
19 @ £1 5s.	23	15	0			
	£1,043	5	0			
1956. 1 @ £2	2	0	0			
1957. 12 @ £2 10s.	30	0	0			
4 @ £2	8	0	0			
Balances	0	10	0			
1959. 6 @ £2 10s.	15	0	0			
2 @ £2	4	0	0			
2 balances	0	15	9			
				1,103	10	9
Miscellaneous receipts					14	3
				£1,147	10	11

Payments.

	£	s.	d.	£	s.	d.
Salary	790	17	0			
Superannuation	78	13	0			
	869	10	0			
Less Government Grant	475	0	0			
				394	10	0
Northern Branch share of subscriptions 1957				119	7	6
Books	16	11	11			
Journals	121	2	1			
	137	14	0			
Less Repayment of sub. to journal	10	11	6			
				127	2	6
Meetings. Attendants, films, &c.	53	5	8			
Notices—postage	39	1	8			
	92	7	4			
Less Rent for Royal Society Room	88	10	0			
				3	17	4
Petty cash:						
Postage re subs.	26	12	4			
Miscellaneous	42	6	0			
				68	18	4
Window cleaning				6	8	0
Electricity				83	5	0
Insurances				25	13	9
Telephone and post box				16	0	0
Subscription to Library Association				1	0	0
Equipment				11	18	0
Stationery				87	5	11
Postage on Papers and Proceedings				22	16	9
Miscellaneous expenditure				33	4	1
Transfer to Reserve Account				50	0	0
Balance to next Account				96	3	9
				£1,147	10	11

A. M. D. HEWER, Auditor.

J. W. C. WYETT, Vice-President.
G. E. A. HALE, Hon. Treasurer.

Northern Branch.

Annual Report, 1958.

The Annual General Meeting of the Northern Branch of the Royal Society of Tasmania was held at the Queen Victoria Museum on 21st March, 1958, when the following were elected to the Branch Council:—

Chairman (1958-1959): Mr. G. H. Stancombe.
Vice-Chairman (1958-1959): Dr. C. Craig.
Hon. Secretary/Treasurer (1958): Mr. W. F. Ellis.
Past Chairman (1958-1959): Mr. G. H. Crawford (ex officio).
Members of Council: Mr. R. S. Smith, Mr. R. H. Stewart, Mr. John Lord.

The following members of the Branch Council continued in their term of office for 1958: Mrs. I. J. Mead, Dr. J. H. Wilson.

Owing to a transfer from Tasmania, Dr. Wilson resigned in May and Mr. J. R. Rex was elected in his place.

Mr. Justice G. H. Crawford represented the Branch on the Cradle Mt.-Lake St. Clair National Park Board.

Activities During 1958.

Nine General Meetings and two Special Meetings were held during the year at which the following papers were presented:

General Meetings:

21st February: "National Parks in Canada" by Mr. F. N. Lakin, Dip. Mech. Eng., A.M.I.E. Aust.
21st March: "Legal Life in Launceston a Century Ago" by Mr. Justice G. H. Crawford, LL.B.
2nd May: "Pioneering in Tasmania" by Mr. J. R. Skemp, B.Sc.
19th May: "The Study of Floods and their Control" by Professor C. H. Munro, B.E., A.M.I.E. Aust.
20th June: "Old Tasmanian Engravings" by Dr. C. Craig, C.M.G., M.D., M.S., D.D.R.
25th July: "The Problem Buttercup" by Dr. F. J. F. Fisher M.Sc., Ph.D.
29th August: "The Story of Fine China" by Mr. Edward Shaw.
19th September: "The Royal Society of London and its relation to the Royal Society of Tasmania" by Dr. W. Bryden, B.A., M.Sc., Ph.D., F.R.S.E.
21st November: "By cance from Lake Pedder to Macquarie Harbour" by Mr. O. Truchanas.

Special Meetings:

26th April: "Earthquakes in Tasmania" by Prof. S. W. Carey, D.Sc. (in conjunction with the University of Tasmania).
9th October: "Current Scientific Research in the Antarctic" by Mr. P. G. Law, M.Sc.

Four Excursions were held as follows:

20th April: Campbell Town, led by Mr. G. H. Stancombe.
1st June: Launceston Filtration Plant, led by Mr. W. F. Ellis.
28th September: Lefroy, led by Mr. Justice G. H. Crawford.
29-30th November: Hobart, led by Mr. G. H. Stancombe.

Some of the recommendations of the Sub-Committee concerned with the improvement of the Branch activities were implemented during 1958 although lack of finance necessitated many limitations. Unfortunately, for the same reason, the promising work in locating and preserving historical material had to be suspended, it is hoped but temporarily.

The first section of the transcription of the diaries of John Helder Wedge with notes and biographical study were submitted to the Standing Committee of the Society for publication and the remaining portion of the diaries are in preparation.

The Branch Council wish to record its appreciation of the services and facilities provided by the Queen Victoria Museum, without which it would be unable to maintain the present standard of activities.

Statement of Accounts at 31st December, 1958.

Receipts.	£	s.	d.
Balance at 1.1.1958	116	0	5
Share of subscription	119	7	6
Bank interest	4	12	3
Sales of publication	27	17	7
Bus fares received (see contra)	40	0	0
Sundry receipts	4	15	4
	£312	13	1

Expenditure.	£	s.	d.
Lectures	44	1	11
Library	12	9	10
Printing, stationary, advertising	33	10	9
Postages	38	17	8½
Hire of transport (see contra)	45	0	0
Purchase of projector	44	19	4
Sundries	3	6	1½
Balance in bank	87	17	5
Cash in hand	2	10	0
	£312	13	1

W. F. ELLIS, Honorary Secretary.

H. C. A. PITT, Honorary Auditor.

Calliuncus vulsus nom. nov. (Opiliones).

By

V. V. Hickman

Ralston Professor of Biology, University of Tasmania

In Vol. 92, page 53, of the Papers and Proceedings of this Society, published in 1958, I described under the name *Calliuncus glaber* a new Tasmanian harvestman. Prof. Dr. C. F. Roewer has kindly drawn my attention to the fact that H. Kauri (1954, p. 7) has given the name *Calliuncus glabra* to a harvestman from South-West Australia. The word "*glabra*", however, is incorrectly formed and must be changed to "*glaber*", thus causing the name for the Tasmanian species to be preoccupied. Hence it becomes necessary for a new name to be given to the Tasmanian form and I therefore propose the name *Calliuncus vulsus*.

The two species differ from each other in the armature of the femur of the pedipalp.

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Papers and Proceedings of the Royal Society of Tasmania, Volume 93

THE PRECAMBRIAN ROCKS OF TASMANIA, PART IV— THE MT. MULLENS AREA

By

Alan Spry
Department of Geology, University of Tasmania,

and

Don Zimmerman
Department of Geology, University of Queensland

(With 2 Plates and 1 Map)

ABSTRACT

The area about Mt. Mullens (Lat 42° 13′ S., Long. 145° 52′ E.) in Central Western Tasmania is underlain by rocks of Precambrian age, with a possible area of Ordovician sediments in the south-eastern corner, and a discontinuous veneer of Pleistocene glacial and fluvioglacial sediments. The Precambrian rocks are from oldest to youngest, the Joyce Group (garnet-mica schists) overlain by the quartz schists, quartzites and phyllites of the Mary Group, next garnet-mica schists, correlated with the Franklin Group in a downfaulted block. Jane Dolomite occurs in the south-east, and Scotchfire (?) Group phyllites, schists, calc-schists and dolomites occur immediately to the east of the area. There may be a major unconformity below the Jane Dolomite. The Scotchfire (?) sediments have been intruded by pre-metamorphic basic igneous rocks. The area is divided up into an eastern and a western structural unit and the contact of the two units is shown to be a fault. The Precambrian sediments have been regionally metamorphosed in varying amounts and range in grade from unmetamorphosed (?) Jane Dolomite, through the chlorite zone to the garnet zone. The sediments were folded into the Collingwood Syncline during the Tabberabberan Orogeny and are strongly faulted. Evidence of two phases of Pleistocene glaciation is seen in the area, an earlier extensive ice-cap and a later, less extensive, valley phase.

INTRODUCTION

This area was mapped as part of a regional investigation by the Hydro-Electric Commission of Tasmania under the direction of D. O'Driscoll and Professor S. Warren Carey.

The major part of the field work was done by D. Zimmerman with the assistance of D. Woolley, during January and February, 1955. A. Spry carried out a reconnaissance through the area in the summer of 1954 and spent a further week in the field during October, 1956. The compilation of the map and preparation of the paper was carried out by A. Spry. The specimen numbers are those of the rock catalogue in the Department of Geology, University of Tasmania.

ACKNOWLEDGMENTS

The base map was prepared from air photos by the Hydro-Electric Commission, by whose courtesy this paper is published.

PREVIOUS LITERATURE

No detailed work has been carried out in this area previously, although a reconnaissance of the Loddon River-Jane River area was described by Ward (1908, 1909a), and Ward (1909b) summarized the knowledge of the Precambrian rocks of Tasmania. Brief surveys of the Jane River, Prince of Wales Range, Surveyor Range and Deception Range were described by Finucane and Blake (1933), and Blake (1936, 1937). The glacial physiography was referred to by Johnston (1894a, b), Lewis (1944), and Moore (1896).

PHYSIOGRAPHY

The area possesses considerable relief with altitudes over 2,000 feet in places. It shows a rugged mature surface which has been chiefly moulded by fluviatile action, and the valley glaciers which were active only a few miles away up the Franklin, Surprise, Stonehaven and Alma Rivers probably did not erode the land surface here appreciably .

The major physiographic unit to the east, north and north-west is the Central Plateau, which is underlain by Jurassic dolerite, with Permian and Triassic strata. Remnants are visible at the King William Range, Mt. Gell and the Eldon Range. The Mt. Mullens area represents the deeply dissected infra-structure of the Plateau where not only have the flat-lying Permian, Triassic and Jurassic rocks been removed, but the pre-Permian surface has been obliterated.

As in most parts of the surrounding district, the highest points, e.g., Mt. Hardy (2,900 feet), Mt. Mullens (2,200 feet), Junction Peak (2,150 feet) and the Collingwood Range (2,500 feet) are underlain by quartzites of the Mary Group. By contrast, the schists of the Franklin Group and the Jane Dolomite form low rounded hills. The Collingwood range forms an excellent strike ridge with the hard quartz-schists dipping west at 70° and

has the form of a steep cuesta or a hogback with a very steep scarp which rises 1,300 feet above the flat plain of the Collingwood River. Cuestas are only crudely developed elsewhere and the strike of the rocks is commonly quite oblique to the long ridges.

The area is dominated by the drainage system of the Franklin, Collingwood and Loddon Rivers, whose courses have been strongly controlled by the geological structure in some places.

The Franklin River has its source in the strongly glaciated Plateau-remnant of Mt. Gell and in its upper reaches possesses many glacial features. It begins in the rock basin, Lake Hermione, drops into a second rock basin, Lake Undine, then descends to the south down a U-shaped valley for ten miles until it is joined by the Surprise River coming from the east. The Surprise also is clearly glaciated in its upper reaches, but neither river shows glacial forms for several miles above their junction.

In the area mapped here, the Franklin varies considerably in character. Near the Jane River track huts, it has cut 40 feet through a well-developed terrace, but, nevertheless, possesses meanders and a divided course. The bed-rock is the Jane Dolomite which is overlain by Pleistocene glacial and fluvioglacial sediments. Downstream the river crosses a fault and enters the quartzites of the Mary Group and to the south of Artist's Hill its course becomes straighter and constricted for about a mile. Prior to the Pleistocene glaciation the river was apparently held up by the quartzites which formed a local base level and the river cut a broad flood plain upstream in the softer Jane Dolomite. During the Pleistocene at least 60 feet of glacial sediments were deposited in the river valley. The river once meandered across this material and cut several 10-feet-high terraces, now visible near the highway where they have a thin upper layer of normal river deposit, but has cut 40 feet through this terrace. Further downstream there are further developments of broad terraces.

The river turns south-west at Junction Peak and changes character markedly. Upstream from here the river is mature and runs parallel to the strike of the sediments, but beyond Junction Peak it cuts a youthful gorge across the structure and shows the superimposed characteristics which were described further downstream by Spry (1957b).

Both the Alma and the Stonehaven have their heads in the glaciated country around Mt. Gell and Gould's Sugar Loaf and possess U-shaped valleys for the first few miles. Then they pass into broad valleys choked with glacial and fluvioglacial debris and covered with button grass. The Stonehaven, in the north-south stretch a mile or so north of Artist's Hill, wanders through glacial debris with a very irregular flat course until it turns west at Artist's Hill and cuts steeply down to join the Franklin.

The Collingwood River leaves the high country north-east of Bubb's Hill and shows a fairly broad straight, mature valley which follows the trend of the rocks as the strike swings from about 110° near the Raglan Range to 150° at the Collingwood Range.

The Junction Peak quartzite has acted as a local base level to the Collingwood also, and upstream from this there is a broad terrace almost a mile wide and two miles long, through which the river has become entrenched by about 120 feet.

The upper surface of this terrace has an altitude of a little over 1,200 feet, with small hillocks rising to 1,250 feet, and the terrace in the Franklin just south-east of Artist's Hill has the same altitude. This latter terrace is underlain by Pleistocene fluvioglacial sediments and the extensive flat area around Stonehaven Creek (just north of Artist's Hill), which is covered by glacial materials, lies between 1,200 and 1,250 feet also. There are button grass flats up the Alma River for several miles above its junction with the Collingwood; these lie between 1,200 and 1,250 feet altitude lower down but rise to about 1,400 feet further upstream.

It is suggested that these flats represent a comparatively undissected level formed by deposition of glacial sediments in the late Pleistocene. A few miles away to the north-east and east it would be underlain by till but in this area only by fluvioglacial or glacioiacustrine materials. The varved mudstones suggest strongly that there has been damming of the Collingwood and Franklin. The altitude of the river itself before the glaciation was only a little higher than at present but a lake formed extending for several miles up the Collingwood, Franklin, Alma and Stonehaven. There was up to 100 feet of sediment deposited in this lake and its river tributaries, leaving at the end of the glaciation a fairly level surface of deposition at about 1,225 feet, but rising upstream. Since the Pleistocene the rivers have cut right through this soft material and have begun to erode the bed-rock beneath.

The probable position of the dam which caused the lake is an interesting problem. The narrow gorge at Junction Peak would be easiest to dam but the only reasonable explanation would be a landslide. It may be significant that the Loddon Plains have an altitude of between 1,200 and 1,250 feet, thus suggesting that the dam was further downstream than the Loddon-Franklin Junction. There is no way of being sure at present how much of this 1,200-1,250 surface is due to older normal river erosion related to some base level downstream, especially with regard to the Loddon Plains, but if these Plains are cognate with this surface to the north, it allows a ready explanation of the damming. Frenchman's Cap was glaciated during the Pleistocene and evidence of smaller glaciers coming down to low levels on the north, east and south is clear. It is not unreasonable to suspect one such tongue of coming down the glaciated valley which joins the Franklin from the south almost two miles west of the Loddon-Franklin junction and actually reaching the Franklin to dam it up temporarily to the 1,200-1,250 feet level.

Structural Control of Physiography

As is commonly found in this district, there is only a moderate degree of structural control of the physiography. The quartzites of the Mary

Group form the highest points and in some cases there are strike ridges of quartzites. The Franklin and the Collingwood run parallel to the strike upstream from Junction Peak and the un-named river just west of the Collingwood Range follows a major fault. The tributaries of the Franklin and Loddon in the Mt. Mullens area show a rectangular pattern determined by the strike of the sediments and by small faults and joints. There are a few small sinkholes in the Jane Dolomite along Carbonate Creek and these occur even on parts of the steep valley wall.

Glacial Control of Physiography

As there are Pleistocene glacial deposits in this area, it is perhaps surprising that the land surface shows no characteristic glacial forms and this is attributed to the fact that this represented the marginal zone for much of the glaciation with deposition predominating over erosion.

The upper parts of the Surprise, Franklin, Alma and Stonehaven have clearly been shaped by glaciers, probably during the most recent phase of the Pleistocene, but the U-shaped form ceases at least five miles upstream from here on all of these rivers. No evidence such as roches moutonnées or smoothed rock surfaces was found in this area.

On the other hand, there are large boulders of Jurassic dolerite on the top of Artist's Hill (about 1,800 feet altitude) and thus approximately 600 feet above the present valley floor. Boulders of Crotty Sandstone at an altitude of about 1,300 feet on the south side of the Franklin River (co-ordinates E388-N801) are probably not *in situ* and have been transported.

Glacial sediments occur in the cliff cut by the Franklin River south-east of Artist's Hill (south of the 34 mile post from Queenstown) where there are varved mudstones containing erratics, till and fluvioglacial sands and conglomerates. Many exposure of fluvioglacial sediments may be seen along the Lyell Highway, particularly near Stonehaven Creek. Extensive deposits of till which contains abundant Owen Conglomerate occur along the Jane River track about 2½ miles south of the Franklin River.

It is not possible to recognise the dam which caused the lake into which the early-formed varves were deposited. There may once have been a large terminal moraine a little upstream from Junction Peak. During the period of maximum glaciation the ice probably extended down the Franklin to the Collingwood-Franklin junction. It is notable that dolerite boulders occur in deposits along the Collingwood for about four miles upstream from the junction although no more were found further up. This suggests that the ice may have passed from east to west and have been diverted by the Collingwood Range, up the Collingwood valley.

It seems likely that there was an extensive, major ice-cap phase which deposited the dolerite boulders on top of Artist's Hill, followed by a lesser valley glacier phase which was restricted to the headwaters of the Franklin, Stonehaven, Alma and Surprise, &c.

A similar twofold division in the glaciation was recognised at the Arm River by Spry (1958) and it may be possible to correlate the glacial phenomena of the two areas. One very important difference, however, lies in the degree of weathering of the till. At the Arm and Mersey Rivers, even the silt-size particles of pyroxene and feldspar in the till were fresh, and the dolerite boulders were unweathered. In the Mt. Mullens area some boulders of dolerite up to a foot in diameter are found to be completely weathered through.

The difference in the degree of weathering suggests that the Franklin glacials are much older than those of the Mersey, but in contradistinction to this is the fact that many of the dolerite boulders in the Linda moraine (dated by Gill 1956, as 26,400 ± 800 years old by radio-carbon) are completely weathered. We are faced with three possible alternatives: (1) the climate has differed so much in the two areas since the glaciation that dolerite erratics were weathered in the Franklin-Linda area, but not in the Arm; (2) the extensive glaciation in the Arm-Mersey-Forth area took place after the Linda episode, i.e., took place less than 26,000 years ago; (3) there is some error associated with the radio-carbon dating.

At present it seems that the first alternative is most likely but it is quite clear that much more field work and more actual dating is necessary to clarify Tasmania's glacial history.

STRATIGRAPHY

The area is chiefly underlain by rocks of Precambrian age which are correlated with the Joyce, Mary and Franklin Groups and the Jane Dolomite. A correlate of the Scotchfire Group occurs just east of the area where it probably underlies the Jane Dolomite. The sequence of Joyce Group (oldest), followed by Mary Group and the Franklin Group (youngest), is fairly clear, but there is no direct evidence in this area of the stratigraphic position of the Jane Dolomite and Scotchfire Groups, although there is some indication that the Jane Dolomite is the youngest Precambrian formation present. Altered basic igneous rocks occur within the Scotchfire Group and these are correlated with the Older Basic Igneous Group (Spry, 1957b) to the west. Lower Palaeozoic rocks, extending from the Owen Conglomerate up into the Eldon Group, occur in the valley of the Loddon River immediately to the south, and these may extend into the south-eastern corner of the area where they are covered with the Pleistocene glacials which are widespread there.

The Precambrian rocks which are almost entirely sedimentary, show evidence of low to medium grade regional metamorphism and strong deformation and have a total thickness of about 20,000 feet.

Precambrian Rocks

Mary Group

A considerable development (approximately 12,000 feet) of quartz schists, massive quartzites and phyllites, is correlated with the Mary Group, which has its type area immediately to the west. Despite the complexities of structure, the similarity

in lithology and thickness and the continuity of outcrop are sufficient to make this a reliable correlation.

It is not possible to give a stratigraphic sequence of formations within this group in this area and reference may be made to the sequence given by Spry (1957b) a few miles to the west. One difference, however, lies in the lack here of the typical dark-grey phyllites such as occur at the base of Mt. Mary. The phyllites in the Mt. Mullens area are less abundant, are paler in colour and richer in silica. It was suggested by Spry (1957b) that the quartz schists might have been formed from the phyllites by silicification, and, if this is so, then there has been a regional increase in silicification from west to east, i.e., from Mt. Mary to Mt. Mullens. On the other hand, it is quite possible that the difference in silica content is a primary feature of the sediments and that there was a facies gradation with more argillaceous varieties occurring to the west.

The massive quartzites, such as those on Mt. Mullens, are characteristically ripple-marked.

Franklin Group

About 4,000 feet of mica schists, some of which are garnetiferous, outcrop along the Collingwood River and the Lyell Highway, north of Junction Peak, but their stratigraphic relations are obscure.

They might be considered to dip beneath the Collingwood Range quartz-schist and thus be the Joyce Group, or they could be faulted against the quartz-schist and thus belong to the Franklin Group. The two alternatives are outlined below.

The schists might be correlated with the Joyce Group because they have the same dip and strike as the Collingwood Range quartz-schist (Mary Group) and appear to dip regularly beneath it along a contact which curves through 40° over its exposed distance of two miles. Garnet schist and quartz schist occur, apparently undisturbed, within ten yards of each other, and a dark phyllite in this zone has characteristics common to the Mary and Joyce Groups. Similar garnet schist dips in a similar fashion beneath similar quartz schist on the other side of the Collingwood Syncline only four miles away, and this was interpreted as being the Joyce Group dipping beneath the Mary Group and there is no evidence yet to suggest that this is incorrect.

On the other hand, these rocks are also lithologically identical with schists of the Franklin Group and there is a continuous outcrop of such rocks along the Lyell Highway to the Raglan Range, where they certainly belong to the Franklin Group. In clarification of this point, it should be noted that there is at least one major fault between here and the Raglan Range and that, whereas the strike swings gently round, the direction of dip changes abruptly from south-west to north-east across the fault. A further point in support, is that the quartzite near the 26-mile post on the Lyell Highway, occurring within the schists along the Collingwood River, is lithologically very similar to the Raglan Quartzite in the Franklin Group.

The second choice is preferred on structural grounds and the evidence suggesting that these schists belong to the Franklin Group is given in the structural section on page 6.

Jane Dolomite

Dolomite occurs over a broad area as outcrops in the bed of the Franklin River around its junction with Carbonate Creek, and extending for at least a mile up the latter. It varies in lithology from a massive or thickly-bedded grey or buff dolomite to a dolomite breccia. The breccia consists of angular fragments of dolomite, mudstone, quartzite and schist, usually a few inches across but reaching a foot in some places, set in a dolomite matrix. Similar breccia occurs in the Jane Dolomite at Christmas Rock and elsewhere. Irregular silicification of the dolomite has given rise to white, grey and black cherts.

The attitude of the dolomite is difficult to determine, but in general it strikes at about 320° and dips at 60° to the south-west, and if this is constant, the bed would be several thousand feet thick, but, as it is not possible to see the top and bottom, a thickness of 3,000 feet is very tentatively advanced.

A detailed description of the dolomite breccia is given in the petrology section and it seems clear that the breccia marks a hiatus of some kind, although it is a little difficult to estimate the magnitude of the break. The evidence for the hiatus is as follows:—

(1) The Jane Dolomite is fine grained, and apparently unrecrystallized, unmetamorphosed and undeformed, even though to the south it rests directly on the Lachlan Conglomerate, which is strongly sheared and metamorphosed, containing biotite and chloritoid, or on the Scotchfire Group, which is also strongly deformed and metamorphosed.

(2) The dolomite breccia contains pieces of unmetamorphosed mudstone together with fragments of schist.

(3) The breccia is composed chiefly of large, angular fragments of dolomite identical with the underlying massive dolomite and thus containing some particles of local, and probably penecontemporaneous, origin.

(4) It contains fragments of mica schist which clearly had been metamorphosed prior to the deposition of the breccia. Some of the larger particles are similar to the local Precambrian rocks.

The first conclusion obtained from this evidence is that the breccia was derived from erosion of *local* rocks and that it marks a period of at least local tectonic uplift.

A second, more important conclusion, based on these facts needs investigation on a regional basis. If the dolomite is indeed unmetamorphosed and undeformed, then the base of the dolomite marks a major unconformity and it was deposited after erosion of the previously metamorphosed Precambrian rocks. It would then be older than the Ordovician Owen Conglomerate but younger than the adjacent Precambrian schists, and thus might be Upper Precambrian.

Scotchfire Group

These rocks do not actually occur within the mapped area, but appear to underlie the Jane Dolomite to the east, being well developed along the Lyell Highway. Prominent is a pale-green, lustrous phyllite with a strong lineation. Thin dolomites occur also and some of these are oolitic, and some have been silicified to white, grey or black chert. Thin quartzites are present and calc-schists (dolomitic phyllites) outcrop on the Lyell Highway near the mile post 38 miles from Queenstown.

Pleistocene Sediments

There are sediments with glacial and fluvioglacial appearance, particularly in the eastern part of this area and these are attributed to the Pleistocene Epoch. The glaciation has been discussed in the physiography section.

No measurements of thickness and sequences were made, but in the river terraces of the Franklin, south-east of Artist's Hill, there is a total of at least 40 feet and probably nearer 60 feet. The lowermost bed here is a varved mudstone, about 10 feet thick, and this contains numerous erratics in some parts. It is overlain by cross-bedded sands with discontinuous conglomerates and a probable till.

Up on the sides of Artist's Hill, the basal bed is a till containing thoroughly weathered dolerite boulders, but just a little north of here and slightly downhill the lowest bed is a thinly-bedded, fine-grained sandstone, resembling the varve in the Franklin River.

The till on the south side of the Franklin, almost opposite the cage on the Frenchman's Cap track, contains boulders of fossiliferous Crotty Sandstone up to four feet across and the till which occurs along the Jane River track, two miles south of the Highway is rich in large Owen Conglomerate boulders. Most of the till in this area, however, contains a large number of Jurassic dolerite boulders.

STRUCTURE

The major structure of the Mt. Mullens area is the Collingwood Syncline which runs across the western side. The beds generally strike north-westerly and dip to the south-west at an average of about 60°, thus forming the eastern limb of the syncline. The Franklin Group occurs as a down-faulted block along the Collingwood River.

This area lies on an important structural zone. A western structural unit is composed of rocks of the Franklin, Mary and Joyce Groups, and an eastern structural unit is composed of rocks of the Scotchfire Group and Jane Dolomite, together with those of the Lower Palaeozoic, Junee and Eldon Groups. It is not possible at present to recognize fully the relationships between the two units, but in this area at least they are separated by a fault of major dimensions (the Artist's Hill Fault). The nature of this fault and its amount of movement cannot be stated at present.

Major Folds

The Precambrian rocks were broadly folded during the middle Palaeozoic Tabberabberan Orogeny but the folding appears to have followed Precambrian trends and to have been associated with considerable faulting.

Mary Anticline

The Mary Anticline is very prominent immediately to the west but is difficult to follow into this area. It plunges flatly to the east-south-east and the axis appears to merge with that of the Collingwood Syncline.

Collingwood Syncline

This is an asymmetrical syncline with the west limb dipping at an average of 35° and the east limb at an average of 50°. The axis runs along the valley of the un-named river just west of the Collingwood Range, trending at about 320° in the northern part and swinging to about 20° near the southern boundary, but it is difficult to find the continuation of this fold beyond the boundaries of this area. It is faulted along the axial zone by a steep thrust fault which is discussed below. The convergence of the thrust faults associated with the Mary Anticline, Collingwood Syncline and Loddon Syncline is striking.

Beyond the northern boundary the position of the synclinal axis is also indefinite. There is a major synclina axis north of the Collingwood River trending at about 300°, but if this is the Collingwood Syncline it has been offset by several miles. It might well be equivalent to the minor faulted syncline in the north-east of the map-square immediately to the west.

Faults

There are a large number of faults in this area some of which are of considerable magnitude and the more important are given names. The faults may be divided up into groups according to their direction, but it is probable that most of them, if not all, are cognate and were formed practically simultaneously during the Tabberabberan Orogeny. Many of the faults are curved in plan and several may be followed for nearly fifteen miles.

(1) There is a set of faults trending east-south-easterly in the area to the west. These were mapped by Spry (1957b) and it was shown that some, at least, were faults of large magnitude (greater than 5,000 feet throw) and were probably steep thrusts. One such fault can be followed from the King Valley up the Governor River, where it trends west-south-west, just to the north of Flat Bluff, down the Joyce Creek, where it trends east-south-east, and past Ward's Bluff to the Franklin River west of Junction Peak.

This fault, and others of the set, disappear against the Junction Peak Fault, which is described below. Another fault of this set, south of Mt. Madge, curves in a similar fashion to the fault mentioned above, passing north of the Franklin River to the Loddon River, then parallel to the East Loddon River beyond the new Jane River track.

(2) It is considered that there is a major fault along the axis of the Collingwood Syncline. It is a high angle reverse fault which has moved the flatter-dipping beds of the west limb which lie near the base of the Mary Group up over the more steeply-dipping beds of the east limb, which are near the top of the Mary Group. Evidence supporting the existence of this fault, which is named the Junction Peak Fault, is as follows:—

(*a*) Dips and strikes are strongly discordant in many places across the axial zone, e.g., at co-ordinates E393-S803 the axis strikes at 185° and the beds on the east limb strike at 300° and dip south at .0°, whereas the beds on the west limb strike at 300° and dip north at 30°. There is a similar occurrence at co-ordinates E395-S802.

(*b*) Many of the major faults, which enter the area from the west, end at a line marking the axis of the fold.

(*c*) The beds immediately to the west and east of the axis appear to be separated stratigraphically by several thousand feet. In the south-western part of the area it appears that the beds on the west limb are about 2,000 feet above the base of the Mary Group, whereas those on the east are about 8,000 feet above the base.

(*d*) It is possible to follow a linear on the air photos from a known fault near Bubb's Hill across to the line of this fault. The sense and amount of movement measured independently at Bubb's Hill and in this area are the same, i.e., north or east side down about 6,000 feet.

The Junction Peak Fault appears to end against the east-west thrust on the Loddon River mentioned previously.

(3) There is a block, one mile across and at least three miles long, composed of garnet and mica schists, extending along the Collingwood valley, north of Junction Peak. These schists were tentatively correlated with the Franklin Group on page 7.

The best explanation for the occurrence of an isolated mass of schist, surrounded on three sides by the lithologically quite dissimilar Mary Group, is that it is a downfaulted block.

The fault of the southern boundary of the block is seen just north of Junction Peak, where the mica schists to the north pass abruptly into quartzite to the south along the strike.

The fault on the eastern boundary of the block is indicated by the crushing exposed in the road cutting just west of the large creek, which is west of the 30-mile post from Queenstown.

The curved nature of the western boundary of the schist and the comparative lack of contortion there does not greatly favour the hypothesis that it is a fault, but it should be remembered that many of the faults in this area are curved and that many of the major thrusts are unaccompanied by obvious crushing and drag.

This block appears to lie along a continuation of the downfaulted zone at Bubb's Hill. In this locality there are a number of long blocks of the Eldon and Junee Groups which have been downfaulted at least 6,000 feet into the Franklin Group which surrounds them on three sides. The appearance of the block of Franklin Group schist at the Collingwood River is very similar.

The two faults bounding the eastern and western sides of this block are named the Mt. Hardy Fault and the Alma Fault and are shown on the map. They are parallel to and cognate with the Junction Peak Fault and thus with the faults at Bubb's Hill. The Bubb's Hill system, then, appears to consist of a group of faults extending from the King River to Junction Peak, i.e., for 15 miles. It forms a zone 1-2 miles wide and curves in direction from 280° in the west to 350° at Junction Peak and 10° at the Loddon River. There are cognate faults transverse to the system. It might correspond with the Linda Disturbance at Mt. Lyell, which is only seven miles west of the known westernmost limit of this system, and directly in line with it. As some of the faults in the Linda Disturbance and near Junction Peak are steep thrusts, it seems possible that some of those at Bubb's Hill are thrusts also.

(4) There is a fault in a direction 325° from the 34-mile post on the Lyell Highway and it is named the Artist's Hill Fault. It separates rocks of the Mary Group, striking at about 280° and dipping south-west from the Jane Dolomite, which has a similar attitude. This is a very important fault which marks the contact between two structural units in this area.

It is not possible yet to determine either the type of fault or its amount of movement because of lack of knowledge of the stratigraphic relationships of the rocks in the structural units, but it seems possible that it may be a Precambrian fault of very large throw, possibly with later Palaeozoic movement.

(5) There is a set of faults which trend north-north-easterly and which are probably normal faults of small throw. This group is common in the Mt. Mary area but is less important here. There are a number of these on Mt. Mullens, but the most important are those faults, trending at 60°, which displace the Collingwood Range quartz-schist, in the north-western part of the area.

PETROLOGY

The petrographic character of the most important rock types is given and this is discussed from a purely stratigraphic viewpoint to show how the major stratigraphic groups can be distinguished from each other, and to allow comparisons with adjacent areas.

A detailed study of the petrology of the rocks in this and the adjacent areas is now in progress.

The Precambrian rocks in this area consist almost entirely of regionally metamorphosed sediments with some minor pre-metamorphic basic intrusives. The grade of metamorphism is different in the different stratigraphic groups, as the Jane Dolomite is apparently unmetamorphosed, the Scotchfire and Mary Groups belong to the chlorite zone (muscovite-chlorite subfacies of the greenschist facies of Turner and Verhoogen, 1951), and the Joyce and

Franklin Groups belong to the garnet zone (chloritoid-almandine subfacies of the albite-epidote amphibolite facies).

Mary Group

This is composed of massive, white siliceous rocks (here called "massive quartzites"), platy, white siliceous rocks with some sericite (here called "quartz schists"), and light-grey foliated, sericite-rick rocks (here called "phyllites"). This follows the nomenclature used for similar rocks by Spry (1957b).

The fundamental difference between these three rock types lies in the composition, and in particular in the relative proportions of quartz and sericite. Differences in the quartz-mica ratio have resulted in structural differences because of their different methods of deformation. The coarse-grained quartzites behaved differently from the fine-grained, mica-rich phyllites.

The massive quartzites are coarse-grained, non-schistose rocks, with not more than 1% to 2% of mica. The quartz schists are fine, even-grained rocks with a distinct foliation and contain about 10% to 20% of mica. The phyllites are very fine grained rocks with a strong foliation and contain up to 50% of mica.

Massive Quartzite

Specimen 6827 from the Collingwood Range is a typical massive quartzite. It is white in colour, well bedded, and has grains of quartz visible in the hand specimen. In thin section it is moderately coarse grained with a mortar texture. Large (up to .5 mm.) xenoblastic quartz grains, showing undulose extinction, are set up in a matrix of quartz grains about .15 mm. across, showing a slight tendency towards elongation.

Quartz Schist

Specimen 6970 is a typical example from very near the base of the Mary Group and it outcrops just west of the Franklin River, ¼-mile north of its junction with the Loddon River. It is a white, fine-grained, platy quartzite, with sericite visible on the foliation planes. A distinct lineation is caused by tiny crenulations. In thin section it is a very fine-grained rock, consisting chiefly of quartz grains ranging in size from .05 mm. to .2 mm., together with about 10% sericite as tiny parallel flakes giving the foliation. The quartz shows a slight tendency towards elongation and shows undulose extinction. Accessories are well rounded zircon, rutile, a little iron ore and abundant tourmaline showing a skeletal form.

Specimen 6815 occurs in the un-named large creek west of the Collingwood Range in the vicinity of the Junction Peak Fault. In hand specimen it is quite similar to the rock described above, but the microscope shows it to be much more strongly deformed. It is a rather fine grained quartzite with a pronounced foliation produced chiefly by strong elongation of the quartz grains, together with a little parallel sericite. The quartz grains show undulose extinction and are crossed by parallel lines of opaque inclusions which traverse the whole slide.

It is possible that the trains of inclusions mark the original bedding and that the schistosity has been produced at an angle to this. It at first appears significant that the most deformed rock found in the Mary Group occurs very close to a major fault and has a schistosity which dips and strikes (strike 360°. dip 60° W.) parallel to the fault whose attitude was determined independently. Throughout the area, the general degree of deformation and the foliation are clearly not related to the faulting, which can be shown to be later than the metamorphism, but it is possible that some of the faults were formed during the Precambrian with repeated movement in the Tabberaberan.

Franklin Group

This consists chiefly of mica schists with some garnetiferous and albite-rich varieties and some which are sufficiently coarse to be called gneisses.

Specimen No. 6799, from the Lyell Highway, 29½ miles from Queenstown, is a fine-grained, light-grey crenulated schist. In thin section it is a moderately fine-grained, schistose rock consisting of quartz (60%), muscovite (15%), chlorite (15%), and albite (about 10%), with accessory rutile, tourmaline, zircon and iron ore. The quartz ranges in size from .05 mm. to .2 mm. and forms xenoblastic interlocking crystals, some of which are elongated parallel to the schistosity. The albite forms shapeless crystals with abundant inclusions and a few crystals are twinned.

Specimen No. 6800, from just north of the Franklin-Collingwood junction, is somewhat similar except that it contains more muscovite and no chlorite. It shows one foliation due to bands of muscovite flakes with a second lesser foliation at 20° to the first in the quartz-rich layers between the bands. The albite occurs mostly as small lenticular crystals rimmed with iron ore and embedded in the mica-rich layers. The quartz is elongated parallel to the major foliation.

Specimen No. 6801, from the Lyell Highway, 28½ miles from Queenstown, is a silvery-grey schist with small garnets. Under the microscope, it is a fine-grained schistose rock consisting chiefly of quartz and muscovite with lesser garnet, chlorite and biotite. The quartz is elongated parallel to the foliation which is marked by layers of parallel muscovite flakes. The garnet has been replaced by chlorite.

Specimen 6797 occurs ¼-mile east of the Lyell Highway, up the creek which crosses the Highway 27¾ miles from Queenstown. It contains large crenulated porphyroblasts of biotite, some of which have been chloritized, set in a fine-grained schistose matrix rich in quartz and muscovite.

Jane Dolomite

This consists of massive dolomite together with dolomite breccia, but, as a large number of thin sections of the former variety in the type locality to the south consist merely of a fine-grained aggregate of dolomite with a little quartz and talc, only the breccia is described in detail here.

The breccia is massive and unbedded and contains angular fragments, chiefly of dolomite, but some of unmetamorphosed mudstone, up to several feet across, the majority being a few inches across. In thin section the rock consists of angular fragments of all sizes in a dolomite matrix. Most of the fragments are composed of dolomite; some are very fine grained, but others are irregularly recrystallised with coarser veins and patches through the fine-grained carbonate.

Some particles are composed of quartz and muscovite with a distinct schistosity and are classed as fine-grained schist. One such grain contains a number of idioblastic tourmaline crystals. The direction of schistosity is constant for any given grain, but is unrelated in adjacent particles.

There are a few fragments of extremely fine-grained slate and siltstone and some rather coarse, even-grained quartzite.

The matrix consists chiefly of idioblastic dolomite rhombs, together with quartz, sericite and a little pyrite.

Scotchfire Group

The glossy, pale-green phyllites and fine-grained schists, together with thin dolomites. dolomitic schists, quartzites, slates and basic intrusives, extending along the Lyell Highway from the 34-mile post almost to the King William Saddle, are correlated lithologically with the Scotchfire Group. Specimens 7152, 7703 and 7706 illustrate some of the schists of this group.

Specimen 7152 is a dark-grey, lustrous phyllite from the Lyell Highway below Mt. Arrowsmith. It shows a strong foliation and lineation. Under the microscope it is seen to be a fine-grained rock consisting of quartz (about 50%) and sericite (40%) with abundant chlorite and accessory tourmaline and iron ore. The quartz ranges between .04 mm. and .1 mm. in size, whereas the sericite is very small. The schist shows three distinct foliations.

Number 7703, from the Lyell Highway near the 40-mile post from Queenstown, is a dolomitic schist. It is a very pale brown, glossy, fine-grained, contorted schist with a distinct lineation (fine crenulation). In thin section it is a banded and schistose rock, cosisting chiefly of quartz, sericite and dolomite. The structure is complicated because there are three distinct foliations, and these complexities will be dealt with elsewhere.

Specimen No. 7706, from the Carbonate Creek, a little over a mile up from its junction with the Franklin, is an excellent sample of a calc-schist. It is a dark-grey, lustrous, fine-grained schist with bands of fine-grained dolomite parallel to the foliation. Under the microscope it is seen to be a fine-grained schistose rock consisting of approximately 40% dolomite, 40% quartz and 20% of mica (sericite and chlorite), with accessory tourmaline and iron ore.

Older Basic Igneous Group

There are at least two small exposures of metamorphosed basic igneous rock to the east of this area. They are tentatively correlated with the pre-metamorphic basic intrusives of the Mt. Mary area because of the severe shearing they have suffered, even though they are of a lower metamorphic grade. Specimen No. 7704 was taken from a small quarry about a chain south of the Lyell Highway in the disused picnic grounds on the Surprise River about 35¾ miles from Queenstown. It was recorded by Finucane and Blake (1933) and presumed to be a Cambrian intrusive, but the authors think that it is more likely to be of Precambrian age. Microscopically, it is a fine-grained, rather schistose rock with a greenish-grey colour and contains abundant small porphyroblasts of epidote, chlorite and feldspar.

In thin section it is schistose with large fractured crystals of albite and lenses of chlorite set in a fine-grained matrix of albite, actinolite and chlorite. Epidote occurs as scattered large crystals and rutile is accessory.

The large (.9 mm.-4 mm.) crystals of albite are dusty with inclusions and are shattered; augen shapes are common and some crystals are sliced through with fracture planes. The feldspar of the matrix occurs as tiny (.05 mm) grains and is fresh, clear and untwinned. It occurs somewhat patchily and looks as though it has been derived from large crystals which have been smashed up and mixed with other secondary products.

There is about 5% to 10% of idioblastic epidote in prisms up to .5 mm. long; it is pleochroic in pale yellows and has a 2V of about 80°-ve.

Lenticular masses from .5 to 2 mm. across of chlorite are pale-green, pleochroic and almost isotropic. It has probably replaced large pyroxene crystals.

A pale-green actinolite occurs abundantly as needles in the groundmass where is forms a poorly-directed mesh with albite, epidote and chlorite.

The augen shapes, schistosity and fragmentation all indicate considerable deformation, but from the lack of preferred orientation of the actinolite, there has probably been a good deal of post-kinematic crystallization of amphibole.

The assemblage albite-epidote-actinolite-chlorite is typical of the greenschist facies, whereas the albite-hornblende-garnet assemblage of the amphibolites in the Franklin Group is of distinctly higher grade and belongs to the albite-epidote-amphibolite facies.

Specimen No. 7705, from just east of the 34-mile post from Queenstown, on the Lyell Highway, is possibly related to the above. It is a light, greenish-grey rock, fine-grained and weakly-schistose with a mottled appearance. In thin section it is seen to be a fine, even-grained rock consisting of chlorite, albite and sericite with a little ilmenite and apatite. The only signs of any original igneous structure are a few scattered laths of albite and some skeletal grids of ilmenite.

The chlorite, which is pale-green and almost isotropic, forms a fine mesh. There is a set of parallel planes cutting the rock; these are marked by lines of tiny opaque granules and parallel chlorite flakes.

The feldspar is albite and occurs both as large prisms, some of which show Carlsbad twinning and

sericite flakes along the cleavage, or as shapeless granules in the groundmass.

Small flakes of sericite occur together with the chiorite flakes and in parts these have reacted to give small, pleochroic flakes of biotite. This indicates that the rock is in the transition stage from the muscovite-chlorite to the muscovite-biotite sub-facies of the greenschist facies.

Conclusions

As elsewhere in this region, there is a difference in the degree of metamorphism of the different stratigraphic groups. The Jane Dolomite seems unmetamorphosed; the Mary and Scotchfire Groups belong to the chlorite or lower biotite zone (greenschist facies), whereas the Joyce and Franklin Groups belong to the garnet zone (albite-epidote-amphibolite facies). This problem was mentioned by Spry (1957b) and is at present being investigated.

Locality Index

	Internat. Grid Reference K/55	S. Lat.	E. Long.
Alma River	Lyell 58	42° 7′	145° 59′
Artist's Hill	Lyell 58	42° 12′	146° 0′
Bubb's Hill	Lyell 58	42° 7′	145° 45′
Carbonate Creek	Lyell 58	42° 12′	146° 0′
Christmas Rock	Lyell 58	42° 22′	145° 52′
Collingwood Range	Lyell 58	42° 10′	145° 53′
Collingwood River	Lyell 58	42° 10′	145° 50′
Eldon Range	Murchison 51	41° 59′	145° 50′
Flat Bluff	Lyell 58	42° 10′	145° 44′
Forth River	Sheffield 35	41° 25′	146° 15′
	Middlesex 45		
Gould's Sugar Loaf	Lyell 58	42° 4′	146° 59′
Governor River	Lyell 58	42° 12′	145° 42′
Jane River	Pillinger 65	42° 28′	145° 50′
Joyce Creek	Lyell 58	42° 10′	145° 48′
Junction Peak	Lyell 58	42° 13′	145° 56′
King River	Strahan 57	42° 10′	145° 30′
	Lyell 58		
King William Range	King William 66	42° 20′	146° 8′
Lake Hermione	St. Clair 59	42° 7′	146° 3′
Lake Undine	St. Clair 59	42° 6′	146° 3′
Lake Dixon	St. Clair 59	42° 8′	146° 3′
Loddon River	Lyell 58	42° 16′	146° 0′
	King William 88		
Mersey River	Sheffield 37	41° 19′	146° 28′
	Middlesex 45	42° 12′	146° 4′
Mount Arrowsmith	St. Clair 59		
Mount Gell	St. Clair 59	42° 9′	146° 1′
Mount Hardy	Lyell 58	42° 11′	146° 59′
Mount Madge	Lyell 58	42° 7′	145° 45′
Mount Mary	Lyell 58	42° 12′	145° 50′
Mount Maude	Lyell 58	42° 13′	145° 48′
Mount Mullens	Lyell 58	42° 13′	145° 59′
Queenstown	Lyell 58	42° 5′	145° 33′
Stonehaven River	Lyell 58		
(Creek)	Lyell 58	42° 12′	145° 59′
Surprise River	St. Clair 59	42° 15′	146° 3′
	King William 66		
Surveyor Range	Pillinger 65	42° 24′	145° 52′
Ward's Bluff	Lyell 58	42° 11′	145° 52′

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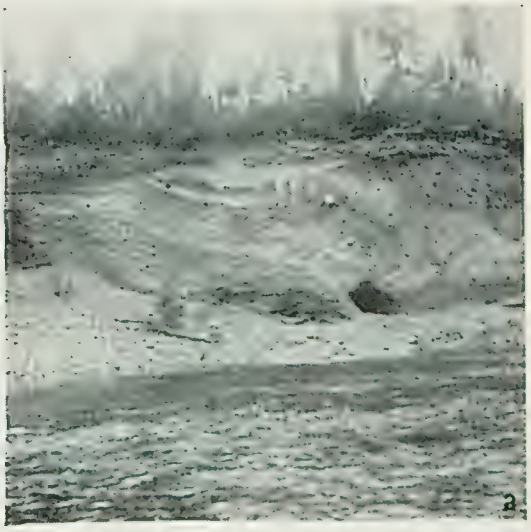


PLATE I.

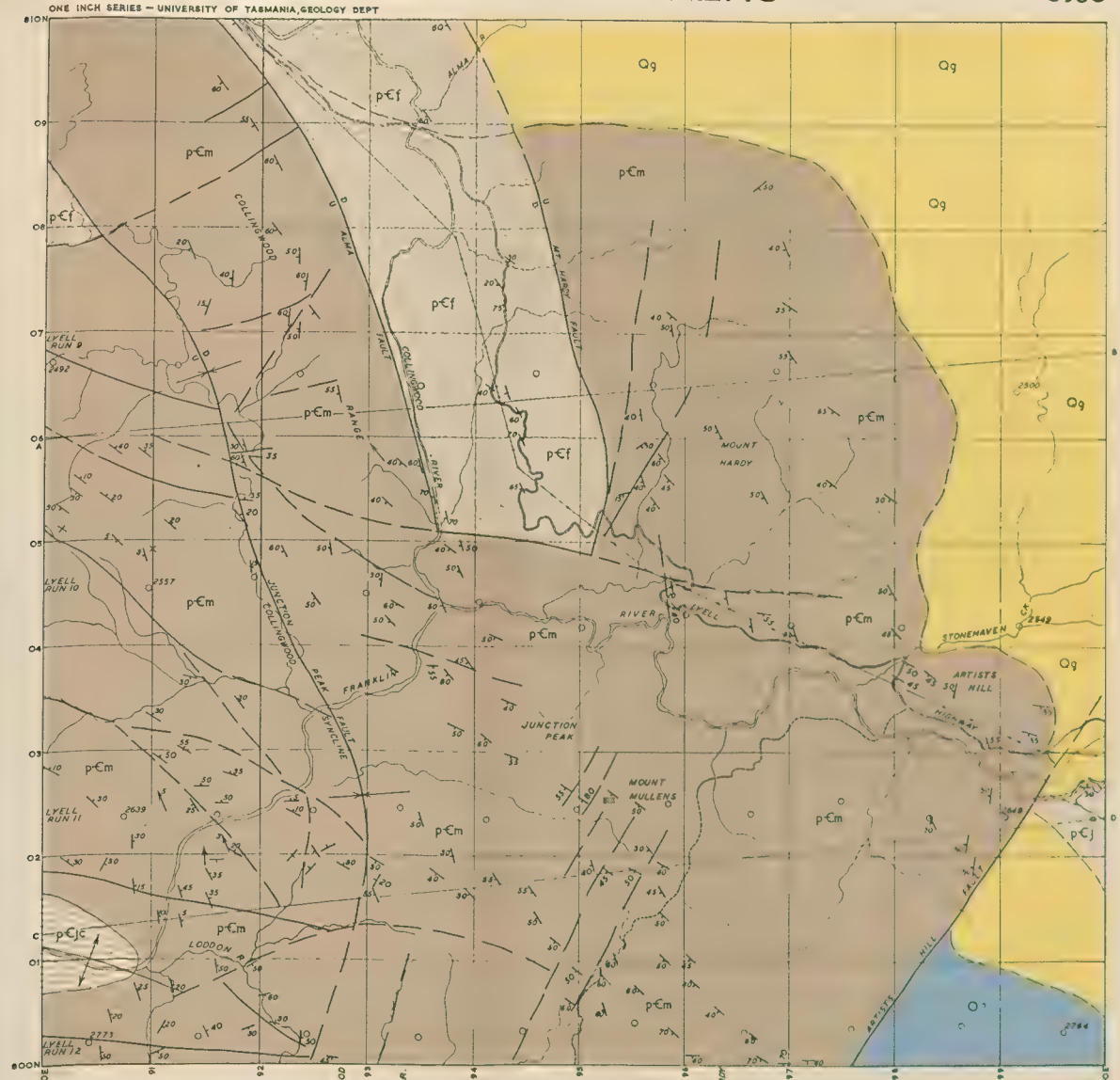
PLATE II.

GEOLOGY OF TASMANIA

ONE INCH SERIES — UNIVERSITY OF TASMANIA, GEOLOGY DEPT

MOUNT MULLENS

3980



Pleistocene Series

Qg GLACIAL AND FLUVIOGLACIAL SEDIMENTS

Ordovician System

O UNDIFFERENTIATED SEDIMENTS

Precambrian

p€J JANE DOLOMITE

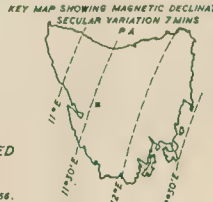
p€f FRANKLIN GROUP

p€m MARY GROUP

p€Jc JOYCE GROUP

MAPPED AND COMPILED BY A. H. SPRY AND D. O. ZIMMERMAN — 1956.

KEY MAP SHOWING MAGNETIC DECLINATIONS SECULAR VARIATION 7 MINS P.A.



Compilation from Aerial Photographs. Trigonometric Station Control by courtesy Hydro-Electric Commission Origin of co-ordinates 400,000 yds. West and 1,800,000 yds. South of True Origin of Zone 7.

FORMATION BOUNDARY

FORMATION BOUNDARY APPROX.

U FAULT SHOWING MOVEMENT D

FAULT PROBABLE

SYNCLINAL AXIS

ANTICLINAL AXIS

40 DIP AND STRIKE

PLUNGE OF LINEATION

ROAD

TRACK

TRANSMISSION LINE

\+ HORIZONTAL DIP

GEOLOGY OF THE MT. MULLENS AREA

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LEWIS, A. N., 1944: "Pleistocene Glaciation in Tasmania". **Pap. and Proc. Roy. Soc. Tas.,** 1944, pp. 41-56.

2. STRATIGRAPHIC TABLE:

AGE	GROUP	FORMATION	ROCK TYPE	THICKNESS
Pleistocene			Glacial and Fluvioglacial Sediments	60'?
		TABBERABBERAN OROGENY		
Devonian Silurian Ordovician	Eldon Junee		Possible existence	
		TYENNAN OROGENY (?)		
		OROGENY		
		Jane	Dolomite	3,000'?
		UNCONFORMITY (?)		
Precambrian	Franklin Mary		Mica, garnet schists Quartz schists, massive quartzites, phyllites	4,000' 12,000'
		MINOR UNCONFORMITY (?)		
	Joyce		Garnet-mica schist	?

3. LOCALITIES OF SPECIAL INTEREST.

Pleistocene glacials and fluvioglacials over Jane Dolomite	E399500.N803000
Pleistocene erratics of Crotty Sandstone	E397000.N803000
Pleistocene erratics of Jurassic Dolerite	E398500.N803500
Fault between Mary and Franklin Groups	E395200.N805300

Papers and Proceedings of the Royal Society of Tasmania, Volume 93

THE GLACIATION OF THE KING VALLEY, WESTERN TASMANIA

By

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(With 1 Figure and 1 Plate)

ABSTRACT.

That a glacier once flowed down the King Valley is shown by glacial deposits in this valley and in the adjacent Nelson, Comstock and Linda Valleys. East of Mt. Lyell it was at least 1,000 feet thick, but south of this point it decreased rapidly in thickness due to widening of the valley and to loss of ice to the distributary glaciers in the Linda and Nelson Valleys. During a brief maximum phase the glacier reached the Crotty Plains six miles south of the Lyell Highway and may have just crossed the West Coast Range at Gormanston Gap. A series of retreat stages is represented by moraines in each valley.

A study of aerial photographs indicates that the King Glacier resulted from the conjunction of major glaciers flowing in the North Eldon and South Eldon Valleys. These were fed from the east side of the Tyndall Range and from the Eldon Range respectively.

Evidence of only one glacial phase was found and it is contended that the glaciation was contemporaneous with that at Lake Margaret. A radio-carbon dating of problematical significance indicates an approximately Wisconsin age for the single advance and retreat.

INTRODUCTION.

The existence of glaciation in the West Coast Range area has long been known (Sprent, 1886; Montgomery, 1891; Power, 1892; Dunn, 1894; Johnston, 1894; Moore, 1894; Officer, Balfour and Hogg, 1895; Moore, 1896; and Gregory, 1904). Of these many reports those of Dunn (1894), Moore (1896), and Gregory (1904) are of the most value. The first two of these discuss the glaciation of the Tyndall-Sedgwick-Dora region and Gregory, in reporting on the Linda Valley area, concluded that the glacial deposits of the Linda Valley came from a distributary of a larger glacier in the King Valley. This view has been supported by the work of Bradley (1954) and Carey (1955), but no actual study of the King Valley glaciation and especially of the limits of the glacier has been reported previously.

The present study consisted of a week's field work in the southern part of the King Valley and in the Linda and Nelson Valleys and a careful study of aerial photographs of the West Coast Range and Eldon Range areas. Two of the authors (Ahmad and Bartlett) have also visited the areas around Mt. Sedgwick and Lake Dora.

The authors wish to thank Professor Carey, of the Geology Department, University of Tasmania, who suggested the study of the area, and also to thank Mr. M. R. Banks and Mr. J. Davies for a number of very helpful suggestions. We also wish to acknowledge the help of the Lands Department in making available photostats of their Lyell Sheet prior to publication. Heights are based on aneroid readings in closed circuits on a Mt. Lyell Company bench mark at Gormanston Recreation Ground and were checked, where possible, against the photostats.

PHYSIOGRAPHY.

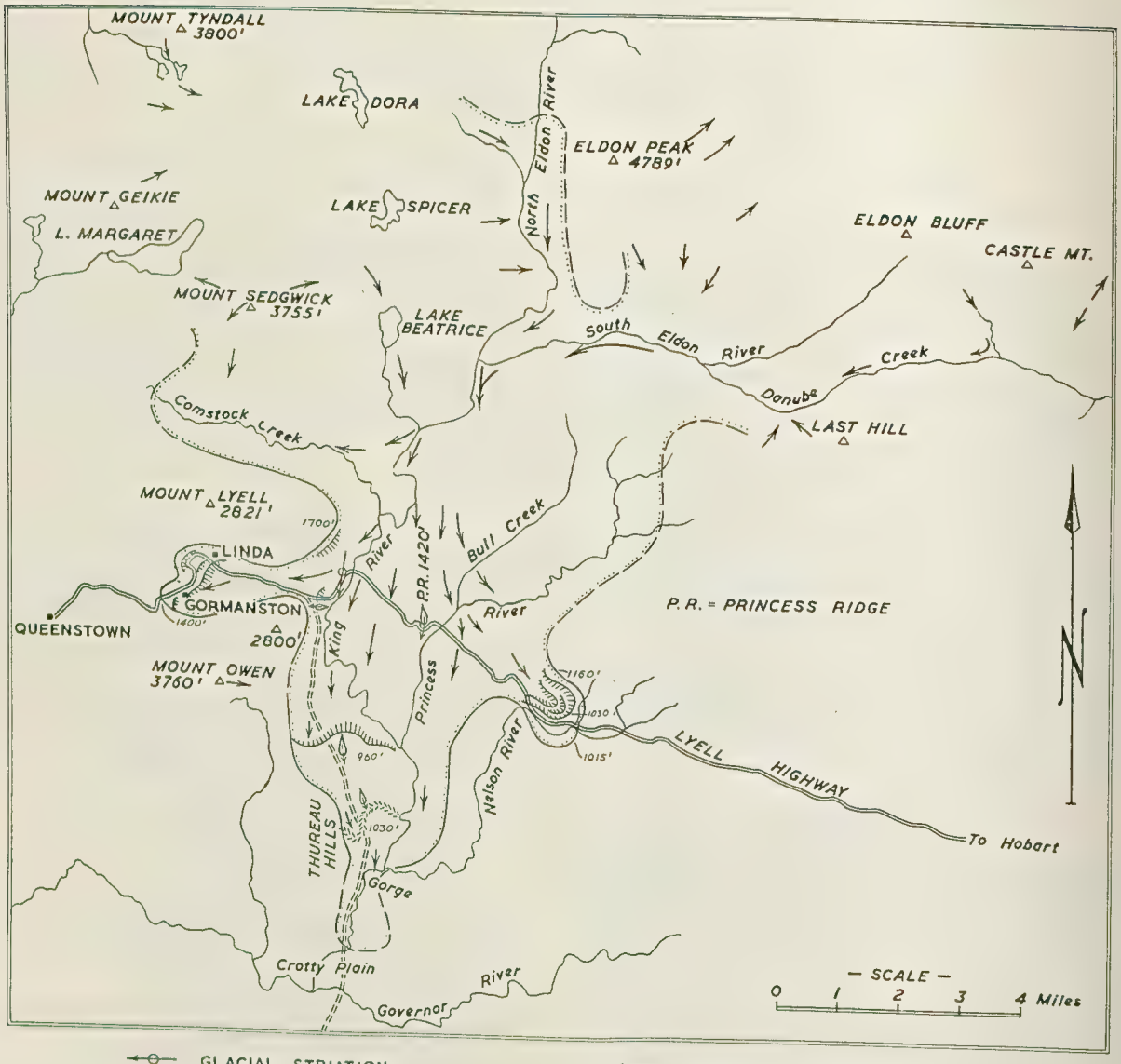
The King Valley runs almost north-south on the eastern side of the West Coast Range and about 20 miles from the western coastline. The valley is crossed by the Lyell Highway about seven miles from Queenstown and there is a vehicle track running south to the Crotty Plain where the King River turns west to flow in a 1,000-feet gorge between Mts. Huxley and Jukes.

The area which must be considered in a discussion of the King Glacier can be divided conveniently into four physiographic units (for localities see Fig. 1):—

(*a*) *The Western Margin of the Central Plateau.*—A strongly-dissected, early-mature area extending west and southwest from near Castle Mt. and Rocky Hill.

(*b*) *The Eldon Range.*—An east-west range which changes from plateau-like near Eldon Bluff to the sharp Eldon Peak (4789 feet) at its western end.

(*c*) *The West Coast Range.*—A series of rugged peaks with Mts. Tyndall (3,800 feet), Geikie and Sedgwick (3,755 feet) in the north forming the western and southern margins of the Dora-Spicer plateau. South of Mt. Sedgwick the range is broken by the broad Comstock Valley (about 900 feet above sea level) and again on the south of Mt. Lyell (2,821 feet) by the Linda Valley (900 feet). South of this valley are the several peaks of Mt. Owen (3,760 feet) and further south-east the Thureau Hills form an eastward extension of the range.



GLACIATION OF KING RIVER VALLEY

Fig. 1.

(*d*) *The King Valley.*—The North Eldon Valley between Eldon Peak and the West Coast Range, and the South Eldon Valley on the southern side of the Eldon Range, join south-west of Eldon Peak and from there the King Valley extends south for a further eight miles as a broad (1-3 miles), flat-floored valley in which the King River pursues a meandering course. East of the Thureau Hills the river passes through a short but narrow gorge before emerging onto the Crotty Plains. The panoramic view (Plate i) shows many of these features.

The Princess River and Bull Creek are small streams in wide valleys separated from the King Valley north of the Lyell Highway by Princess Ridge (1,420 feet) and its northerly continuation. The Nelson River flows west parallel to the Lyell Highway until the latter crosses a 1,030-feet divide to the wide Princess Valley. The Nelson River, however, turns sharply south and finally joins the King River east of the Thureau Hills. In its lower part it is separated from the King by a range of hills about 1,500 feet high.

It may be stressed here that the physiographic features follow the geological structure very closely. The King, Linda, Comstock and Nelson Valleys all owe their existence primarily to the presence of relatively soft Gordon Limestone or Eldon Group sediments. Modifications of the physiography, which are due to glacial action, are present to a varying extent.

THE SOURCE OF THE KING GLACIER.

The King Glacier resulted from the junction of glaciers flowing in the North Eldon and South Eldon Valleys. The main collecting ground for the ice in the North Eldon Valley was in the Tyndall Range to the west. A substantial ice field on the east of the Tyndall Range between Mts. Tyndall and Geikie gave rise to glaciers which dominantly moved east and south-east across Lake Dora and Lake Spicer to spill over the plateau edge into the North Eldon Valley and through Lake Beatrice into the King Valley. The western wall of this valley is an abrupt but moulded and smoothed slope capped by morainal material. A tributary of the North Eldon River, rising just north-east of Lake Dora, flows eastward through a distinctly U-shaped valley and this was probably one of the principal feeders of the North Eldon Glacier.

From the north side of Mt. Tyndall, ice probably also moved northward through Lake Rolleston. The Hamilton Moraine resulted from ice originating probably on the east slopes of Mt. Geikie and flowing south-west through Lake Margaret. As pointed out by Bradley (1954) there was probably no great quantity of ice moving off the plateau in this direction, but, coming from the highest parts of the plateau and falling sharply on to the Henty Peneplain, the terminal position of the glacier stayed essentially constant over a long period of time. This period is probably represented by the many minor fluctuations recorded in the King Glacier and even perhaps lasted until after its retreat to the plateau edge. This would account for the magnitude of the Hamilton Moraine as compared to the magnitude of the moraines of the King Valley.

The area around Mt. Sedgwick is problematical as it is not known whether this acted as a separate source area or whether a portion of the main ice sheet to the north flowed past Sedgwick and spilt south into the Comstock Valley.

There are no cirques of any size on the western side of Eldon Peak but two glaciers from the north side of the peak moved north-east and have left very large lateral moraines. These glaciers meet the valley of a tributary of the North Eldon (flowing north-west here) at right angles but do not appear to have flowed down this valley but rather to have melted at its edge.

From the south-east side of Eldon Peak several glaciers fed into the South Eldon Valley. From the Eldon Range some ice moved south into the South Eldon Valley and some north into the Canning River. From Eldon Bluff a rather larger glacier moved south-east and then south-west along Danube Creek to join the South Eldon Valley. There is an ice divide running approximately from Castle Mt. to Rocky Hill. East of this, ice from High Dome moved into the Canning River and thence to the Murchison River. From the southern side of the South Eldon Valley several glaciers came from the vicinity of Last Hill to flow into the South Eldon Valley.

The South Eldon and North Eldon glaciers seem to have been of similar size by the time they joined to form the King Glacier but the glacier flowing through Lake Beatrice was probably somewhat smaller.

THE GLACIER IN THE KING VALLEY.

Carey (1955) reported a striated pavement near the road bridge over the King River at the base of the eastern slopes of Mt. Lyell. The valley floor is here at 700 feet. West of this point erratics and till occur to a height of 1,700 feet. Benches occur in this slope at 1,700, 1,660, 1,560, 1,220, and 1,120 feet. These benches are apparently of morainal material and are probably small lateral moraines, having depressions, now filled with gravel, behind them. The presence of erratics 1,000 feet above the valley floor indicates an ice thickness here of at least this magnitude. This conclusion is supported by the presence of erratics further east on the summit of the 1,420 feet Princess Ridge which was probably crossed by about 280 feet of ice moving towards the Nelson Valley.

It seems unlikely that ice ever passed between Thureau Hills and Mt. Owen, as the northern entrance to this valley is barred by a solid rock ridge (1,000 feet) which has till on its north face but none on the crest or southern face.

Two miles south of the mouth of Linda Valley a rounded ridge of Eldon Group (Silurian and Devonian) quartzite bears erratics to a height of at least 950 feet but none could be found beyond this to the summit at 960 feet. Thus the upper

limit of the ice was probably very close to the top of the ridge.

The height of the plain on the western side of the hill is 800 feet and, estimating 100 feet as the thickness of glacial deposits on the valley floor, this gives an ice thickness here of at least 250 feet.

This ridge is flanked at its northern end by a very low morainal ridge rising about five feet above the flat plain and apparently extending right across the valley. This is most probably a small end moraine of the King Glacier. The plain extending south of this morainal ridge to the quartzite barrier ridge 3½ miles south of the Linda Valley is probably an outwash plain formed between the retreating glacier and the ridge. There is a fine example of a *roche moutonnée* on this plain just north of the ridge (Plate ii.).

This barrier ridge has a surface veneer of till to a height of 940 feet at its western end. Since the valley floor is at 830 feet at the northern end of the ridge, an ice thickness of not less than 170 feet to 220 feet is indicated if 50 feet to 100 feet be allowed as the thickness of deposits. There is no evidence of an extensive end moraine in the area and a moraine-like ridge immediately south of the point at which the vehicle track cuts through a gap in the ridge is probably solid with only a thin cover of moraine. Lateral moraine occurs on the adjacent slopes of the Thureau Hills. Several terraces to the north-east of the ridge were probably cut by earlier courses of the King River and its tributaries. The dry U-shaped valley cutting through the centre of the ridge has a fan-like deposit at its southern end—this seems to be outwash material.

The small plain between the barrier ridge and the gorge just north of the Crotty Plain is dominantly of outwash material. One section showed sand and clayey sand with some boulders and pebbles resting on basement rock. A section by the vehicle track showed sandy varves. Generally, the character of the plain deposits was that of glacial outwash with little actual till. It is considered that these deposits formed in a shallow lake between the ridge to the north and the moraine-dammed gorge north of the Crotty Plain. The glacier lay behind the ridge to the north during a long retreat stage.

In the side of this gorge the upper limit of till at 740 feet above a rock basement of 650 feet indicates an ice thickness here of about 100 feet. Till and outwash occur on the northern part of the Crotty Plain (620 feet) showing that at the maximum glaciation, probably for only a very short time, the ice passed beyond the gorge.

The ice then retreated from this brief maximum, probably remaining behind the gorge above the Crotty Plain for some time. However, it is thought that for the greater part of its history the glacier remained behind the quartzite barrier ridge 3½ miles south of Linda Valley entrance, sending small tongues of ice through the lower parts and depositing outwash material south of the ridge. From this position—probably corresponding with the period of deposition of the Gormanston Moraine and the higher Nelson Moraine—the ice retreated, irregularly depositing a small recessional moraine two miles south of the Linda Valley entrance, and forming a broad outwash plain north of the barrier ridge. No attempt has been made to correlate these later retreat stages with those represented by the lower levels of the Gormanston Moraine, the moraine at the entrance to Linda Valley, the several lateral moraines on Mt. Lyell and the lower Nelson moraine.

The Nelson Valley.

As mentioned previously, Princess Ridge was probably crossed by about 280 feet of ice moving towards the Nelson Valley. Ice would also possibly have crossed the divide from the South Eldon-King Valley into the basin of Princess River at points further north. The net result was that ice moved towards and into the Nelson Valley.

Dolerite erratics occur to a height of 1,160 feet north of the mouth of the Nelson Valley. Since the valley floor is at about 900 feet, the thickness of ice here would have been somewhat over 260 feet. At the Princess River Bridge the valley floor is at 705 feet so the ice thickness here during maximum glaciation would have been over 455 feet. It would, however, probably be less than the thickness of 1,000 feet in the main King Valley since it represents the thickness of ice crossing the slightly lower northerly extension of Princess Ridge.

At the entrance to Nelson Valley the Lyell Highway crosses two end moraines. The more easterly of these is at 1,030 feet and is concave towards the Princess flats. Till does occur a little further up the Nelson Valley (height 1,015 feet) but no distinct end moraine exists.

A second and later end moraine occurs parallel to and slightly west of the above-mentioned moraine. It is at a height of 965 feet and consists of till (dominantly Jurassic dolerite) interbedded with current bedded sand, gravel and some clay beds. These moraines represent two relatively long-lived retreat stages of the glacier following a short-lived maximum phase.

The Nelson River, prior to the glaciation, probably flowed westward, approximately following the present Lyell Highway, to join the Princess River before the latter joined the King River. This easterly distributary of the King Glacier and the moraines it built up caused the diversion of the Nelson River to the south so that it is now separated from the King River by a range of hills for a distance of four miles, and finally joins the King before this river enters the Crotty Plains.

Comstock Valley.

This valley was not studied in detail; however, till and glacial outwash similar to that in Linda Valley occur at its western end. Erratics of dolerite, Eldon Group (Silurian and Devonian) rocks, and the haematitic silicious breccia capping the Comstock ore body, occur on the north-western slopes of Mt. Lyell, at an elevation of 1,844 feet, 400 yards due west of the Comstock open cut (M. L. Wade, pers. comm.). These indicate that Comstock Valley was filled with ice that had moved from the north-east. However, it need not have entered from the King Valley. It may have been derived from ice spilling over Mt. Sedgwick from the north.

Linda Valley.

As has been pointed out, erratics occur to a height of 1,700 feet on the eastern slopes of Mt. Lyell at the entrance to Linda Valley. In Linda Valley, till occurs to a height of 1,400 feet on Owen Spur, near Gormanston, and varves and till lie on basement rock at 900 feet near Linda Township. Between these two there is a continuous series of till, outwash and varves. A typical part of the section exposed in a gully near the Lyell Highway above Linda is as follows:—

1,090 feet to 1,080 feet—Till.
1,080 feet to 1,050 feet—Bedded till—outwash.
1,050 feet to 1,020 feet—Varves.
1,020 feet to 1,015 feet—Till.
1,015 feet to 960 feet—Varves.
960 feet to ? —Till.

The interbedding of till and varves seems to represent successive advances and retreats of the ice. The deposition of till and varves from a height of 1,400 feet down to 900 feet, with a maximum thickness of 100 to 200 feet at any one point, indicates an overall retreat downhill of the glacier so that successively lower and north-eastward (downhill) deposits were formed during periods of less intense glaciation.

As recorded by Gregory (1904), the tills contain representatives of practically all the rock types occurring in the surrounding districts. Of particular interest is the presence of Jurassic dolerite (diabase of the older workers) and highly fossiliferous Eldon Group quartzites and slates (see also Carey, 1955). Outcrops of similar Eldon Group rocks occur on the floor of the King Valley, while the nearest outcrops of dolerite are on the summits of Mt. Sedgwick and Eldon Peak. The only conceivable route by which these dolerite boulders could have reached Gormanston is by way of the King and Linda Valleys.

The floor of the Linda Valley rises from 800 feet at the mouth of the valley to 900 feet near Linda and 1,360 feet at Gormanston Gap. The thickness of ice would have been over 1,000 feet at the valley entrance, over 500 feet above Linda, and over 40 feet just east of Gormanston Gap. This supports the conclusion of Gregory, based on the presence in the till of "diabase," that the Linda Glacier was a distributary of the King Glacier. The difference in levels would have provided the hydrostatic head for the flow into the Linda Valley.

The fact that at a short distance east of the Gap erratics occur to a height of 40 feet above the level of the Gap suggests that it is likely that some ice spilt over the Gap and rapidly melted on the steep slope of Conglomerate Creek. The sharp V section of Conglomerate Creek favours the idea that only melt-water and not ice flowed down this creek. During the retreat of the ice from this maximum extent the large Gormanston Moraine was deposited. Till, varves and outwash at the mouth of Linda Valley indicate another retreat position of the ice.

THE AGE OF THE GLACIATION.

The authors have found no evidence to suggest more than one glacial stage in the whole of the King, Lake Dora, and Lake Margaret areas . Rather they consider that all the observed features can be explained by a single, though fluctuating, glaciation.

Lewis considered that the glaciation in Linda Valley belonged to the Malanna Stage (the oldest of his three stages) while the Hamilton Moraine belonged to the Margaret Stage (the youngest of the stages). As pointed out earlier, the Linda Glacier was a distributary of the King Glacier and the authors contend that both were contemporaneous with the Margaret Glacier (which deposited the Hamilton Moraine).

Gill (1956) has reported the result of a radiocarbon dating of wood from varves in the Gormanston Moraine as 26,480 ± 800 years. Unfortunately, the exact locality from which this wood was obtained cannot be ascertained. However, it seems possible that it came from deposits containing wood several hundred yards upstream from the Linda Hotel (see Plate iii.). The sequence of beds here suggests that a forest was flooded by a shallow lake and then covered by till during the initial advance of ice up the valley. Presumably, ice then moved over the till to reach the higher ground near Gormanston and later till and varves were deposited during the retreat of the ice.

If the wood is actually from this locality, then the dating of the initial, advancing phase of the King Glacier is 26,480 ± 800 years. This date corresponds with the beginning of the Wisconsin Glaciation of North America. The glaciation of the King Valley may then tentatively be regarded as approximately Wisconsin in age.

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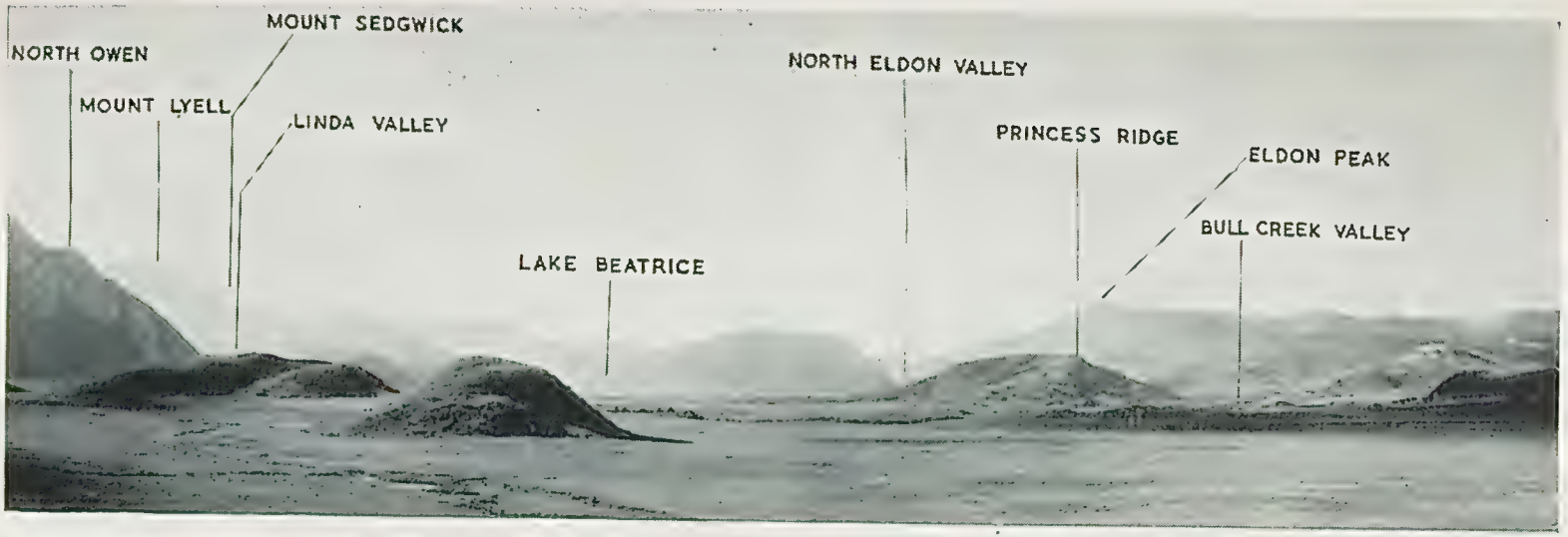
Locality Index.

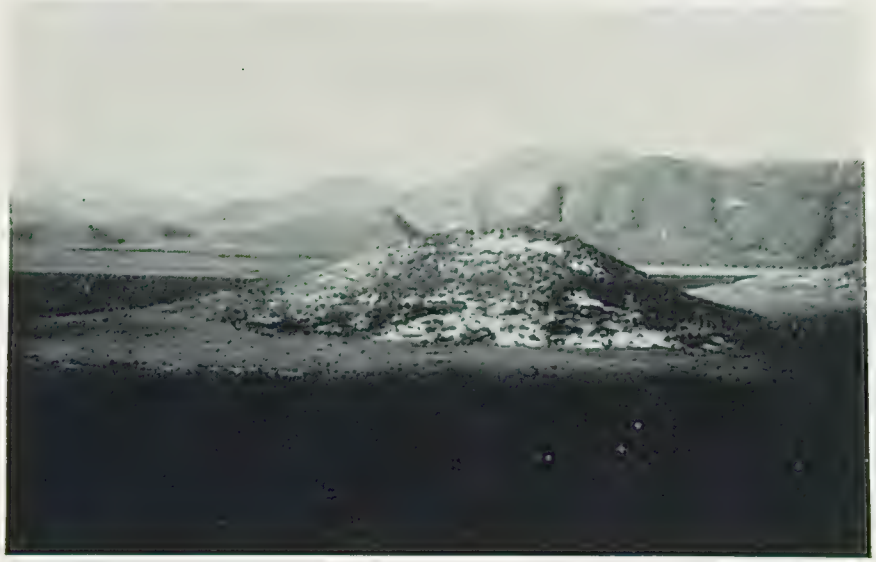
Name	*Quadrangle*	*Latitude*	*Longitude*
Bull Creek	Lyell 58	42° 03′	145° 42′
Canning River	Murchison 51	41° 53′	145° 52′
Castle Mount	Murchison 51	41° 55′	145° 52′
Comstock Valley	Lyell 58	42° 03′	145° 38′
Conglomerate Creek	Lyell 58	42° 06′	145° 35′
Crotty Plain	Lyell 58	42° 10′	145° 39′
Crotty Track	Lyell 58	42° 07′	145° 39′
Danube Creek	Lyell 58	42° 02′	145° 50′
Eldon Bluff	Murchison 51	41° 58′	145° 51′
Eldon Peak	Murchison 51	41° 58′	145° 44′
Eldon Range	Murchison 51	41° 59′	145° 45′
Gormanston	Lyell 58	42° 04′	145° 35′
Gormanston Gap	Lyell 58	42° 04′	145° 35′
High Dome Hill	Murchison 51	41° 59′	145° 57′
King River	Strahan 57 / Lyell 58	42° 04′	145° 38′
Lake Beatrice	Murchison 51	42° 00′	145° 40′
Lake Dora	Murchison 51	41° 57′	145° 38′
Lake Margaret	Zeehan 50	41° 59′	145° 34′
Lake Rolleston	Murchison 51	41° 55′	145° 37′
Lake Spicer	Murchison 51	41° 58′	145° 39′
Last Hill	Lyell 58	42° 02′	145° 48′
Linda	Lyell 58	42° 04′	145° 35′
Linda Valley	Lyell 58	42°04′	145° 37′

Locality Index—*continued*

Name	*Quadrangle*	*Latitude*	*Longitude*
Mt. Gelkie	Zeehan 50	41° 58′	145° 35′
Mt. Huxley	Lyell 58	42° 07′	145° 36′
Mt. Jukes	Lyell 58	42° 11′	145° 37′
Mt. Lyell	Lyell 58	42° 03′	145° 37′
Mt. Owen	Lyell 58	42° 06′	145° 37′
Mt. Sedgwick	Lyell 58	42° 00′	145° 35′
Mt. Tyndall	Murchison 51	41° 54′	145° 33′
Murchison River	Murchison 51	41° 51′	145° 42′
Nelson River	Lyell 58	42° 07′	145° 43′
North Eldon River	Murchison 51 / Lyell 58	41° 48′	145° 42′
Owen Spur	Lyell 58	42° 05′	145° 34′
Princess Ridge	Lyell 58	42° 03′	145° 42′
Princess River	Lyell 58	42° 04′	145° 41′
Princess River Bridge	Lyell 58	42° 05′	145° 40′
Princess Flats	Lyell 58	42° 05′	145° 41′
Queenstown	Lyell 58	42° 05′	145° 33′
Rocky Hill	Lyell 58	42° 03′	145° 53′
South Eldon River	Lyell 58	42° 01′	145° 43′
Thureau Hills	Lyell 58	42° 07′	145° 38′
Tyndall Range	Murchison 51	41° 57′	145° 34′
West Coast Range	Murchison 51 / Lyell 58 / Pillinger 65	41° 44′ / 42° 18′	145° 33′ / 145° 38′



(i) Northern part of King Valley, looking north from *roche moutonnée* figured in (ii).



(ii) *Roche moutonnée*, 3½ miles south of Lyell Highway along Kelly Basin Track and just north of quartzite barrier ridge. View looking east.

(iii) Wood *in situ* in soil beneath glacial outwash, bank of creek west of Linda.

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THE BRIGHTON BASALTS, TASMANIA

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(With 3 Plates and 1 Figure)

ABSTRACT

The Brighton Basalts consist of but a single flow exceeding 150 feet in thickness which flowed down the pre-existing valley of the Jordan River and flooded back up the valleys of the Bagdad and Strathallern Rivulets. Except where the rivers have breached it the surface has been but little modified by later erosion. The complex system of polygonal jointing indicates that the cooling history of the flow was not simple. The basalt is olivine-bearing and its texture varies from doleritic to an extremely fine-grained porphyritic type. The composition of the magma is intermediate between the olivine and tholeiitic magma-types with closer affinities to the latter. Five volcanic necks of basaltic composition occur within the general region of the Brighton Basalts and are regarded as belonging to the same period of volcanism.

INTRODUCTION

Lewis (1946, p. 191) coined the term Brighton Basalts for the extrusive rocks cropping out over some six square miles of the Pontville and Dromedary squares of the Brighton Army map sheet, Tasmania. The general geology of this region has been described by McDougall (1959). All grid references in the text follow the Army usage. The specimens referred to are in the collection of the Geology Department, University of Tasmania.

Owing to the strongly variable direction and angle of dip of the well-developed columns produced by tension during the cooling of the basalt, Lewis (1946) considered that there were many flows, but careful examination of the well-exposed sections in the sides of the river valleys did not reveal any petrographic or morphological break in the basalt which could be ascribed to a boundary between two flows. No sediments, scoriaceous layers or tuffs were observed interbedded with the basalt. The basalt attains a maximum thickness of 150 feet at 119403, near the southern boundary of the Pontville square, but at this locality neither the top nor the bottom of the flow is exposed, so it is possible that the basalt was 200 feet or more in thickness.

FIELD CHARACTERISTICS AND TOPOGRAPHY

The basalt is scoriaceous, vesicular or massive, but it is commonly inhomogeneous as regards the proportion of vesicles, since in places areas of scoriaceous or vesicular basalt occur within otherwise quite massive rock. In some localities the basalt is coarse and even-grained, with almost a doleritic texture, but in general it is a dark-grey, fine-grained rock with phenocrysts of olivine, 1 mm. to 2 mm. in size, visible to the eye.

The edge of the floor of the pre-basaltic valley is exposed only in a few places. For example, at 121414, an excellent exposure occurs of basalt overlying dolerite. Immediately above the dolerite is a five-foot-thick bed of yellow, friable, coarse-grained tuff dipping off the dolerite at about 25° to the west. It is followed upward by from two to three feet of grey, strongly-weathered tuff, which breaks up into thin columns with sides half an inch across. Above this occurs from zero to ten feet of grey scoria, passing into a vesicular fine-grained basalt and then into a massive, relatively coarse-grained basalt. At 108413, on the flanks of Lodge Hill, scoriaceous basalt overlies the dolerite and passes up into massive hexagonally jointed basalt. The basalt dips off the dolerite at about 10° in a south-westerly direction. In the Bagdad Rivulet, at 126471, and along the Hobart-Launceston Highway, betwen the Broadmarsh and Tea Tree turnoffs, much scoriaceous and vesicular basalt occurs. Pipe amygdules, commonly filled with brown opal, are present in many places. It is considered that the basalt, as exposed at these two localities, is near to the base of the flow.

In this area the only evidence as to the age of the basalt is that the topography, onto which the basalt was extruded, was essentially of the same form as at the present, and hence it is of post-faulting age. The basalt, except where the rivers have breached it, remains relatively undissected, suggesting that it was outpoured in comparatively recent times, possibly in the late Tertiary. A number of volcanic necks occur in the area and these are considered to be of the same age. Spry (1955) suggested a Miocene age for the Tasmanian basalts, but later work (M. R. Banks—personal communication) indicates that there is more than one period of volcanism in the Teritary.

The present surface of the basalt rises gently from south to north, and, apart from the gorges and steep-sided valleys cut by the streams, it is relatively undissected (Plate III, figs. 1, 2). It is considered that this surface in general reflects the configuration of the top of the basalt immediately after outpouring and it is probable that only the upper scoriaceous layers have since partly been

Honors Thesis 8, U. of Tas. Grant as Research Student.

removed. The altitude of the surface rises from 180 feet or 190 feet at the southern boundary of the Pontville square to about 235 feet at 118482, 600 yards south-east of Mangalore. However, the basalt extending west from the main Hobart-Launceston road rises steadily to attain an altitude of 290 feet at 088432 on the Broadmarsh road at the most westerly point of outcrop of the basalt. These data suggest that the basalt flowed eastwards down the pre-existing Jordan valley and then south to the pre-basaltic Derwent valley with a branch of the flow flooding back up the Bagdad and Strathallern valleys. Lewis (1946, p. 193) was of the opinion that all the basalt originated from a source in the pre-existing Derwent River valley near Bridgewater.

On the hypothesis stated above, the source of the basalt must be further towards Broadmarsh than the most westerly exposure of the basalt. Two plugs of basalt occur in this region, one at the north-western end of Goat Hill and the other at 046436, west of Limekiln Creek, and these are possibly centres of eruption of the Brighton Basalts. However, the composition of the plugs is markedly different from the basalts occurring to the east. The only alternative, then, for the source of the basalts is that the vent up which they found their way to the surface was covered by the lava.

THE PRE-BASALTIC TOPOGRAPHY

The pre-basaltic topography has been contoured from heights obtained at the edge and within the flow by means of an altimeter. The contours (fig. 1) show that the pre-existing Jordan valley which has now been considerably widened by the present Jordan River. When the basalt filled the old valley the river was displaced to the northern edge of the basalt and has continued to migrate northwards ever since. The base of the basalt at the foot of Lodge Hill has a higher altitude than that at the northern edge of the flow and this is most probably due to the pre-existing valley being asymmetrical in outline with steep slopes rising from the north side of the river, much as it is now. A similar profile is reported by Prider (1947, p. 143) for the basalt near Tarraleah, where there is an increase in thickness from west to east, and he considers the asymmetrical valley to be the result of differential erosion of hard dolerite and softer sediments. In the case of the pre-basaltic Jordan valley, the river cut down through dolerite into Triassic sandstone and gradually migrated northwards in the sediments, producing the asymmetrical valley.

Half a mile south of Pontville the pre-basaltic river valley turned south and maintained that general direction, with minor inflexions, until it joined the Derwent valley. The contours show that the river valley in this part of its course was narrow, with relatively steep sides, because the river was cutting down mainly in resistant dolerite. The pre-basaltic Bagdad and Strathallern Rivulets joined the Jordan valley approximately at the same point as they do at the present time and their courses were similar to those they occupy today. For a short distance a small tributary cut back in a north-westerly direction from the pre-basaltic Jordan River from about half a mile south-west of Brighton.

The gradient of the pre-basaltic Jordan River was greater than that of the present river, since the base of the basalt towards its western margin (170 feet) is considerably higher than the floor of the present valley immediately to the north (110 feet), while the base of the basalt at the southern boundary of the Pontville square is below the floor of the River Jordan of today.

JOINTING OF THE BASALT

Good exposure of the basalt in the valley sides gives ample opportunity for the study of the jointing. In general, the cooling of the basalt has resulted in the formation of polygonal joint columns. At 142449, very well developed vertical hexagonal columns occur with sides up to three feet in size (see Plate I, fig. 1), but in most cases the jointing is far less uniform with the number of sides to the columns varying from three to eight feet. Commonly in the few feet immediately below the present surface of th basalt, approximately vertical columnar jointing occurs. However, further down in the basalt, a number of different patterns of jointing have developed. At 142438, 600 yards east of the Jordan River-Bagdad Rivulet meet massive, practically unjointed, rock at a junction, in one portion of the excellent cliff section, vertical columnar jointing extends only ten feet below the present surface of the basalt to sharp contact. This contact does not remain horizontal; westwards it rapidly becomes lower till at least 70 feet of the 90 feet of the section has columnar joints, which are vertical. The massive basalt towards the bottom of the section has a sub-horizontal joint system with a poorly-developed system approximately perpendicular to it, resulting in irregular joint blocks, which are elongated in an horizontal direction. Massive basalt is present at a number of other localities, but it is by no means general.

Commonly, the columnar joints are sub-vertical and grouped together in the form of "fans" up to 20 yards across. The columns diverge from a central, often complexly jointed, zone up to 10° to 20° from the vertical. Good exposures of columns occur in the railway cuttings on the now disused Apsley railway line south of the junction of the Jordan River and the Bagdad Rivulet (Plate I, fig. 2) and also in the 150-feet-high cliffs at 120403.

In the cliffs of the Jordan gorge at the extreme south of the Pontville square and extending outside it, the columnar jointing is most remarkable. Here the direction and angle of dip of the columns changes considerably even in a short distance. One section, at 115399, has exposed in it two rough shallow "synclines" of columns, which are about 120 yards across. In the south-west, the columns dip approximately 30° to the north-east and decrease in dip to nearly zero and then dip south-west in the north-eastern part of the section. One "syncline" has a large. nearly vertical joint, in an axial plane position, the sets of columns on either side of which have different directions and angles of dip (see Plate I, figs. 3 4, 5).

This type of columnar jointing is not uncommon in basalts elsewhere in the world. Iddings (1909, p. 322) figures a quarry at Orange Mountain, New Jersey, which in many respects is similar to the occurrences described here.

Only in local areas is hackly jointing well developed. In a cliff on the Bagdad Rivulet, 50 yards north of the rifle range road at 140456, twelve feet of hackly-jointed basalt is exposed underlying eight feet of massive basalt.

The cooling history of the basalt flow was a very complex process, as shown by the extremely variable manner of jointing, mainly of the columnar type, and it deserves a much more thorough investigation than it has been possible to carry out.

PETROLOGY

Petrology of the Basalts

The Brighton Basalts can be classified as olivine basalts as the term is used by Johannsen (1937, p. 281). They consist of some olivine (3% to 15%), either as phenocrysts or as granules, but commonly as both; abundant plagioclase, constituting between 30% and 50% of the rock; pyroxene, which comprises between a few per cent and 30% of the rock; a variable proportion of mesostasis (10% to 55%); several per cent of iron ore and minor amounts of introduced silica and calcite.

The olivine occurs as colourless euhedral to anhedral crystals, varying downward in size from 3 mm., which are biaxial negative with a very high optic angle, so that the ferrous oxide content of the mineral is greater than 13% and probably is more like 15% to 25%. Alteration of the olivine to serpentine and/or carbonate is not uncommon. Plagioclase (Ab_{30}-Ab_{50}) as lath-shaped crystals ranges up to 1.4 mm. in length. Twinning is very well developed, the albite type being most common, the carlsbad type less so, while pericline twinning is rarely present. Normal zoning is usually present, the difference in composition between the core and the rim of any one crystal being as much as 20% Ab. Pyroxene, generally as anhedral crystals, ranges from 2 mm. in size down to minute granules which commonly occur in the mesostasis. In most thin sections only augite was definitely identified with its moderate optic angle. However, in some, pigeonite, with its characteristically low 2V, was recognised. Iron ore occurs as minute, often euhedral granules, thin rod-like crystals, and as anhedral grains. In rocks which have a high proportion of mesostasis it is found that the iron ore is confined to it. The mesostasis varies in character according to its abundance. When it constitutes one third or more of the rock it is usually opaque, but does contain some skeletal microlites of plagioclase and pyroxene. However, as the proportion of mesostasis in the rock decreases it becomes grey and then pale-brown in colour and the iron ore, which causes the opaqueness because of its finely-divided state, separates out into discrete crystals. Microlites become very common, but in the end product, when the mesostasis constitutes only about 10% of the rock, it consists essentially of pale-brown isotropic glass.

On the basis of the proportions and grain size of the minerals and textures, it has been possible to recognize five distinct types in the basalt flow, three of which have been previously described by Edwards (1950, pp. 102-103). The five types are:—

1. Ouse type.
2. Bridgewater type.
3. Pontville type.
4. Midlands type.
5. Jordan type.

The Ouse, Bridgewater and Midlands types are those previously defined by Edwards, while the two remaining types are included by him in his three groups, but are here proposed and described as separate types. A summary of the salient features of each type are given in Table 1, the proportions of the various minerals being arrived by micrometric analysis using a point counter.

1. *Ouse Type* (Plate II, Figs. 1, 2)

In hand specimen the rock is dense, dark-grey in colour, massive and very fine grained, while in thin section it is hemicrystalline and has a porphyritic texture with an hyaloophitic textured (Johannsen, 1937, p. 147) groundmass. The phenocrysts, which are of fresh, anhedral to subhedral olivine are set in a groundmass consisting of plagioclase (Ab_{30} to Ab_{40}) laths, olivine granules and an abundant opaque mesostasis. The opaqueness of the mesostasis is due to the presence of very abundant, extremely minute, iron ore granules embedded in it. Plagioclase and pyroxene are present in the mesostasis as microlites, the former as skeletal laths and the latter as granules or skeletal prisms commonly arranged in sheaves. Green opal occurs throughout the rock encrusting small vesicles. This Ouse type of basalt was found at the edge of the Brighton Basalt, at 106393, in a quarry beside the Hobart-Launceston Highway.

2. *Bridgewater Type* (Plate II, Fig. 3)

The rock is dark-grey in colour, dense and fine grained, but contains abundant yellowish-green olivine phenocrysts up to 2 mm. in size. In thin section the rock is porphyritic with olivine phenocrysts set in an hyaloophitic textured groundmass of pyroxene, olivine, plagioclase and an abundant opaque mesostasis. This type is coarser grained than the Ouse type and contains pyroxene as a major constituent. The olivine occurs as anhedral, often strongly embayed, fresh crystals. The plagioclase is a pale-grey augite and occurs as anhedral crystals. There is a tendency for a number of granules of pyroxene to crystallize adjacent to one another to form microglomeroporphyritic plates. The opaque mesostasis occupies about 40% of the rock and contains some small plagioclase microlites and pyroxene granules in addition to rather rare thin rod-like crystals of iron ore. Minor amounts of calcite and yellowish-green opal fill small vesicles. The Bridgewater type is very commonly developed and the following specimens belong to this group: 8364, 8369, 8394, 8395, 9412 and 8419.

TABLE 1.—*Comparison of the Five Different Types of Basalt.*

	Ouse Type, Spec. 8378.	Bridgewater Type, Spec. 8373.	Pontville Type, Spec. 8372.	Midlands Type, Spec. 8370.	Jordan Type, Spec. 8421.
Texture.	Porphyritic, Hyaloophitic Groundmass.	Porphyritic, Hyaloophitic Groundmass.	Porphyritic, Sub-ophitic Groundmass, Intersertal mesostasis.	Ophitic.	Inter-granular.
Olivine (%)	13.2	9.8	8.8	6.5 altered to carbonate and serpentine)	3.3 (altered to carbonate)
Max. Size (mm.)	0.8	2.5	2.5	1.5	1.6
Serpentine %	....	...	2.3	..	....
Pyroxene (%)	In mesostasis as microlites	19.1	21.3	28.9	27.9
Augite (A) and/or Pigeonite (P)	....	A	A	A, P	A, P
Max. Size (mm.)	..	0.5	0.9	2.0	0.4
Av. Size (mm.)	0.05	0.2	0.2	0.8	0.1
Plagioclase %	31.8	30.5	38.6	45.9	41.2
Composition	Ab_{31} Ab_{10}	Ab_{50}-Ab_{10}	Ab_{28}-Ab_{51}	Ab_{30}-Ab_{57}	Labradorite
Max. Length (mm.)	0.35	0.2	0.3	0.9	1.4
Av. Length (mm.)	0.1	0.1	0.1	0.4	0.2
Mesostasis %	54.1	40.5	20.5	12.0	14.3
Colour	Opaque to brown	Opaque	Brown to grey	Brown	Brown
Microlites: Abundant (A), Common (B), Rare (R)	C	R	A	C	C
Iron Ore %	In mesostasis (finely disseminated)	In mesostasis	5.4	3.5	3.7
Opal %	0.9	....	1.4	2.5	0.9
Calcite %	...	...	1.7	0.7	0.7

3. *Pontville Type* (Plate II, Fig. 4)

In the hand specimen rocks belonging to this group are very similar to those of the Bridgewater type, but in thin section the phenocrysts of olivine are set in a sub-ophitic groundmass with an abundant intersertal brown mesostasis. The olivine crystals, which are usually euhedral to subhedral are, in some cases, quite strongly embayed and commonly are altered to serpentine and carbonate. Rarely a small plagioclase lath is included in the olivine phenocrysts. Plagioclase of labradoritic composition occurs as laths, which, in a few cases, form microphenocrysts up to 0.8 mm. in size. Pyroxene is present as anhedral crystals, averaging approximately 0.2 mm. in size and rarely as phenocrysts. The pyroxene is generally an augite with a moderate optic angle. However, in specimen 8375 pigeonite with a very low 2V was definitely identified. Plagioclase is commonly ophitically intergrown with the pyroxene. The intersertal mesostasis is usually light-brown in colour and consists of skeletal microlites of plagioclase and pyroxene set in a base of pale-brown glass which is isotropic and has a refractive index less than that of balsam. Iron ore, as minute, commonly euhedral granules, occurs scattered through the mesostasis and also is present as rod-like crystals up to 0.3 mm. in length, which, within a restricted area, are often oriented parallel to one another. Anhedral crystals of iron ore up to 0.2 mm. in size are also present and practically all the iron is restricted to the mesostasis. In specimen 8382 some small prisms of apatite up to 0.25 mm. in length occur in the mesostasis. Minor amounts of olive-green opal and colourless calcite occur as infillings to small vesicles. Specimens 8375, 8376, 8390, 8396 and 8382 fall into this subdivision quite well, but 8396 is considerably coarser than the average, although it has most of the characteristics of the group.

4. *Midlands Type* (Plate II, Fig. 5)

In the hand specimen the rock is dark-grey in colour and has a dolerite texture with green pyroxenes up to 2 mm. in diameter, easily visible to the naked eye. In thin section the rock has a strongly ophitic texture and consists of plagioclase laths and anhedral pyroxene crystals with relatively minor amounts of altered olivine, iron ore, and a grey-to-brown glassy mesostasis. Some calcite and opal occur in small areas as infillings to vesicles. The composition of the plagioclase varies from calcic labradorite into calcic andesine. The greatest range observed in one crystal, from the core to the thin outer rim, was Ab_{52} to Ab_{57}. The pyroxene, which is pale-grey in colour, includes many pragioclase laths ophitically. Both pigeonite and augite are present and they are commonly intergrown, one often partially enclosing the other. In such cases it is seen that the cleavage runs across the boundary between the two pyroxenes without a break, but owing to differences in optical orientation, a sharp boundary can be discerned in the birefringence. The optical angle of the pigeonite is nearly zero, while that of the augite is about 45°. The mesostasis occurs intersertally between the plagioclase and pyroxene. It is brown to grey in colour and commonly is speckled with minute iron ore granules. The mesostasis has a refractive index less than that of balsam and it is isotropic so that it is mainly glass. It contains a number of colourless acicular microlites of apatite up to 0.1 mm. in length. These commonly contain many minute iron ore granules. Microlites of pyroxene and plagioclase also occur in the mesostasis, but rarely. About 3% of the rock consists of iron ore as lath-shaped or anhedral crystals in addition to the minute granules in the mesostasis Olivine occurs as anhedral to subhedral crystals which have been extensively altered to serpentine and carbonate with only small remnants of the olivine remaining. Calcite, commonly crystallized in a spherulitic manner, and green opal occur as infillings to small vesicles. Specimens 8370, 8371, 8400 and 8410 are included in this group. Although the texture of 8376 is very much like that of the Midlands type, it must be considered to be intermediate in position between this type and the Pontville type since the mesostasis constitutes about 15% of the rock and the plagioclase is a little finer grained. No pigeonite was identified in 8376 and the olivine occurs not as phenocrysts but as granules averaging about 0.1 mm. in size .

5. *Jordan Type* (Plate II, Fig. 6)

Specimen 8421 is a massive, grey, fine-grained rock with common pale-green mineral concentrations up to 1 mm. across, which are altered olivine crystals. Vesicles are present but not abundant. In thin section the rock is fine grained with an intergraular texture and consists essentially of lath-shaped labradorite and granular pyroxene. Iron ore, olivine altered to carbonate, and an intersertal isotropic mesostasis are present in lesser proportions. Opal occurs abundantly, along with calcite, in amygdales. The pyroxene is pale-grey in colour and, as far as can be determined, it is mainly augite, although one crystal was positively identified as pigeonite with its characteristically low optic angle. Iron ore is generally present as anhedral elongate crystals. The intersertal mesostasis is brown in colour, but it is, in some cases, nearly opaque. It contains fairly abundant skeletal microlites which are probably of apatite and are speckled with numerous iron ore granules. The brown base is glass. Abundant (about 9%) dark-green massive opal occurs in irregularly-shaped areas up to 0.8 mm. across and calcite is also present, usually with a spherulitic crystal arrangement. This rock can be compared with the Midlands type, as defined above, but it is rather finer grained, particularly as regards the pyroxene, resulting in an interganular compared with an ophitic texture. It was thought to be sufficiently distinctive to raise it as another type and it is probably included in the Midlands type as originally defined by Edwards (1950). Specimens 8367 and 8374 bear close resemblances to 8421 and are therefore included as members of the Jordan type. The form of the pyroxene is the main difference between the Jordan and Midlands types. In the former it occurs as small granules, whereas in the latter it has crystallized as large plates, including plagioclase ophitically. The reason why in the one case crystallization took place about numerous nuclei and in the other about a few is not known.

Intermediate Types

Although the majority of the basalts fall into one or other of the types outlined above, it is to be expected that there will be rocks intermediate in character between them. Thus specimens 8417 and 8418 have textures which lie between those of the Bridgewater and Pontville types; 8365 lies between the Ouse and Bridgewater types and 8411 between the Bridgewater and Midlands types.

Petrogenesis

Mutual Relationships

The various types of basalt are considered to have resulted from different rates of cooling of a single magma, the position within the flow being the major controlling factor of this rate. The fine grain size and the high proportion of mesostasis in the Ouse type indicate a relatively rapid cooling of the magma and, since the specimen was taken from near the edge of the flow, rapid cooling was to be expected. The phenocrysts of olivine probably had an intratelluric origin, while the granules were formed during and after outpouring. The composition of the magma and the physical conditions were such that the plagioclase began to crystallize, but before the composition or temperature of the magma reached a point where pyroxene could form to any extent, the rock was cooled below the temperature of crystallization. However, the cooling was sufficiently slow to allow crystallization of a small amount of pyroxene as microlites. With slower cooling, the pyroxene was able to crystallize into distinct anhedral crystals and the proportion of mesostasis correspondingiy decreased so that the Bridgewater type of basalt was formed. The large olivine crystals are in some cases strongly embayed, probably indicating partial resorbtion on cooling which is strongly supported by the fact that there is a marked decrease in the proportion of olivine with increasing grain size, i.e., with slower cooling, more time was available for resorbtion to take place.

The Pontville differs from the Bridgewater type, into which it passes, by having a slightly coarser grain size and a tendency towards an ophitic texture. The proportion of pyroxene increases with a corresponding decrease in the amount of mesostasis present. The mesostasis becomes grey to brown in colour and contains abundant microlites and the iron ore begins to separate out into discrete crystals. These observations indicate that the Pontville type was formed by slower cooling of the magma than in the case of the Bridgewater type. With still slower cooling the Jordan and Midlands types were produced with their relatively coarse grain size and very small proportion of mesostasis.

As mentioned above, the types of basalt grade into one another. For example, in the section on the Bagdad Rivulet, 600 yards east of its junction with the Jordan River, specimens 8370, 8371, 8372 and 8373 were obtained from a cliff about 80 feet high. Specimens 8370 and 8371 were taken five and 17 feet respectively above the base of the cliff; at 27 feet specimen 8372 was obtained, while 8373 was sampled from the 75 feet level. There is no sharp textual change observable in the outcrop but it is gradual. Specimens 8370 and 8371 have a coarse ophitic texture with rather minor amounts of porphyritic or granular olivine and a low proportion of mesostasis, i.e., they are of the Midlands type. Upwards, the texture changes to porphyritic with a sub-ophitic groundmass as represented by 8372 (Pontville type). There is a slight increase in the amounts of olivine and a decrease in the proportions of pyroxene and plagioclase with a corresponding increase in the abundance of mesostasis. The grain size of the constituents, except olivine, is reduced considerably. This trend, the reduction in the proportion of plagioclase and pyroxene, but with little change in grain size, is continued upwards and in 8373 (Bridgewater type) over one-third of the rock is composed of opaque mesostasis and the texture remains porphyritic, but with an hyaloophitic groundmass. The Ouse type results from a more rapid cooling than is the case for the Bridgewater type and is not represented in the section being discussed here. However, it is rather surprising that such strong differences in texture occur in this section as it is within 100 yards of the edge of the pre-basaltic valley.

The fact that the rate of cooling, and hence the resultant texture of the basalt, is controlled by the position within the flow rather than its proximity to the sides or floor of the pre-basaltic valley is amply illustrated in 122414. Here a specimen (8404), taken no more than 20 feet from the side of the pre-basaltic valley, has the coarse Midlands type texture. The altitude of the locality from where this basalt was obtained is 90 feet and the top of the flow at 190 feet plus.

In sections where the polygonal jointing is developed right throughout, much more uniform textures of the basalt are found. For example, at 119403, where the basalt is hexagonally jointed for the full 150 feet of exposure, there is no great difference in texture throughout the whole section.

In the late stages of crystallization some alteration of the olivine to serpentine and/or carbonate took place. Hydrothermal solutions, probably also at this time, introduced opal and calcite, with a little chalcedony, into the rocks and deposited them in vesicles. Their amounts vary considerably from place to place.

The Magma Type

Petrographically, the Brighton Basalts have similarities to both the tholeiitic and olivine-basalt magma-types of Kennedy (1933). The presence of augite rather than a pigeonite as the most abundant pyroxene and the ubiquitous occurrence of olivine suggest affinities with the olivine-basalt magma-type, but the glassy residuum, in many cases, charged with iron ore granules, is more typical of the tholeiitic magma-type. Chemically, the three types of basalt defined by Edwards (1950), which are present in the Brighton area, are very similar to one another (see Table II, Analyses 1, 2 and 3). Comparison with the compositions of the two magma-types of Kennedy (1933) (Table II, Analyses 4 and 5) show that the silica content of the Brighton Basalts is typical of the tholeiitic rather than of the olivine-basalt magma-type, whereas the magnesia and lime contents and the soda/potash ratios are similar to those in the

latter. The alumina percentage is intermediate between those of the two types and the iron oxide content is lower than in either type. Edwards (1950) therefore, concluded that the Brighton Basalts are intermediate in composition between the olivine-basalt and tholeiitic magma-types and he also pointed out the strong similarity of the compositions of the basalts with the Newer Volcanic magma-type of Victoria.

TABLE II.

	1	2	3	4	5	6	7	8	
SiO_2	51.48	51.48	50.04	50	45	51.76	50.0	qz	0.18
								or	5.00
Al_2O_3	14.32	14.18	14.47	13	15	12.65	14.3	ab	22.01
Fe_2O_3	2.17	1.56	4.26	13	13	2.37	3.0	an	24.46
FeO	8.98	9.61	7.69			8.88	7.3	di wo	7.66
								di en	4.30
MgO	8.02	8.18	7.89	5	8	8.50	6.6	di fs	3.04
CaO	8.33	8.95	9.35	10	9	9.94	10.9	hy en	16.10
								hy fs	10.56
Na_2O	2.48	2.61	2.47	2.8	2.5	2.19	2.6	mt	2.32
K_2O	0.61	0.82	0.26	1.2	0.5	0.38	0.8	ilm.	3.04
H_2O	0.58	1.00	1.43	....	....	....	0.9	ap	0.67
H_2O-	1.54	0.24	0.52	....	....	....	1.8	H_2O	1.24
CO_2	0.05	tr.	tr.	....	....	....	....	....	100.58
TiO_2	1.45	1.60	1.55	....	....	3.31	1.1	$\frac{(Fe^{2+} + Mn)}{(Fe^{2+} + Mn + Mg)}$ =	40.0
P_2O_5	0.21	0.29	0.23	....	....	0.26	0.4	....	....
MnO	0.14	0.15	0.17	....	....	....	0.2	$\frac{\text{(norm. molec. albite)}}{\text{(norm. molec. Ab + An)}}$ =	47.4
Cl	nil	tr.	tr.	....	....	....	....	....	....
So_3	nil	tr.	tr.	....	....	....	....	....	....
	100.36	100.67	100.33	95	93	100.24	99.9	....	....

1. Ouse type from near Ouse township.
2. Bridgewater type, from 400 yards upstream from bridge, Bridgewater township.
3. Midlands type, from Viney's Sugarloaf south of Nile (Analyses 1, 2 and 3 from Edwards, 1950).
4. Tholeiitic magma-type (Kennedy, 1933. p. 241).
5. Olivine-basalt magma-type (Kennedy, 1933, p. 241).
6. Computed composition of historic magma of Mauna Loa (Powers, 1955, p. 85).
7. Average tholeiite of α-middle fractionation stage (Wager, 1956, p. 231).
8. Normative analysis of analysis 2.

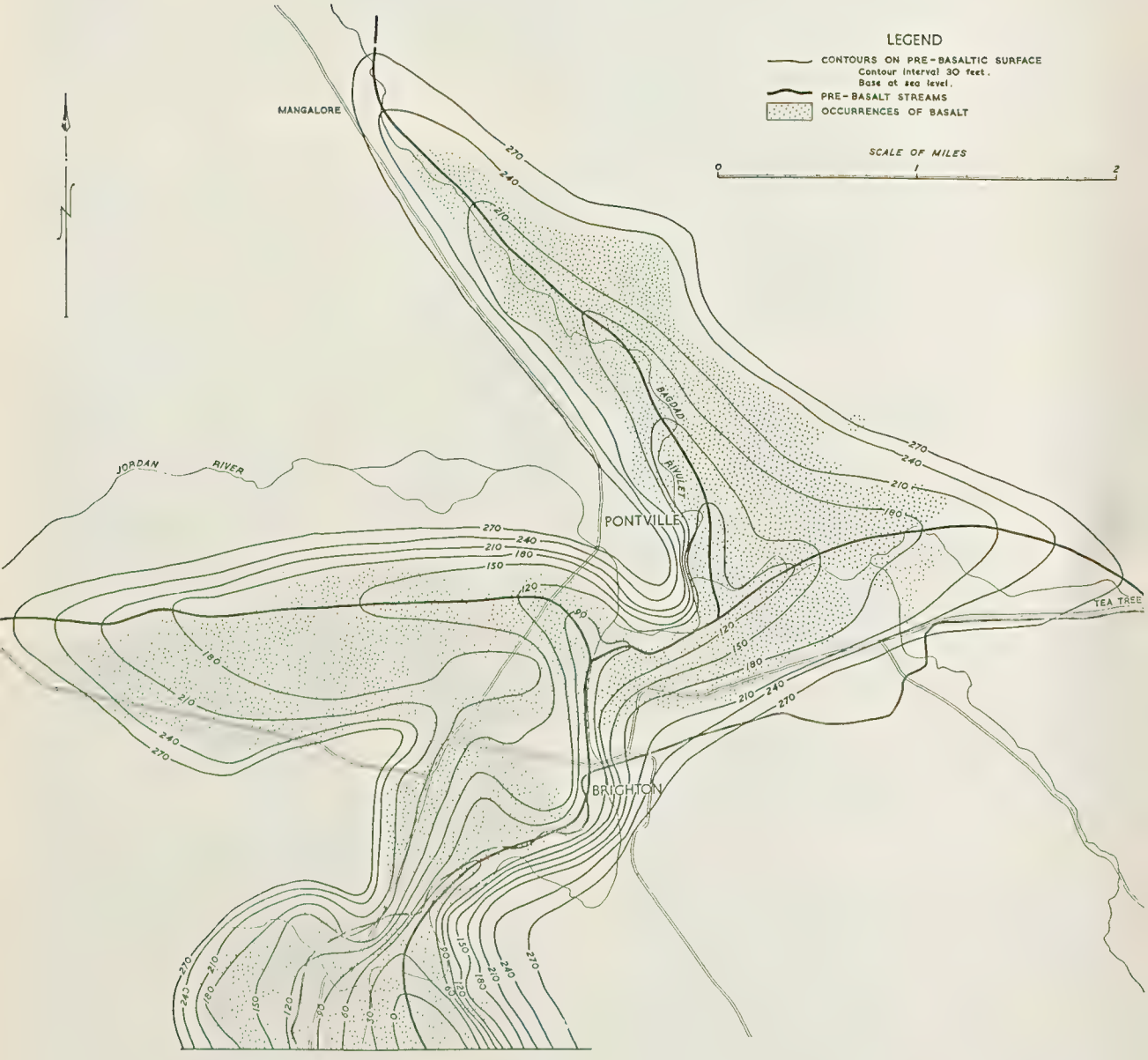

FIG. 1.—Contours on the pre-basaltic surface.

The Brighton Basalts, in many respects, resemble the basalts of the volcanic piles of Kilauea and Mauna Loa in Hawaii. The bulk of the lavas forming these volcanoes are olivine basalts (i.e., contain 5-15% modal olivine), although in the majority of cases the rocks are saturated with silica (Powers, 1955, p. 80) and cannot be included within the olivine-basalt magma-type. The average chemical composition of the magma outpoured in historic times on Mauna Loa (Powers, 1955, p. 80) is quoted in Table II, Analysis 6. The similarity is striking. However, the Brighton Basalts have a slightly higher alumina content and a lower lime and titania content.

The norm calculated for the Bridgewater type (see Table II) indicates that the basalt is just saturated. Yet olivine, an undersaturated mineral, is always present in the basalt. Olivine, when it occurs in basalts, is usually the first mineral to crystallize, but in saturated magmas it is normally resorbed because it becomes out of equilibrium with the magma. This tendency is borne out in the Brighton Basalts by the general decrease in the proportion of olivine in the coarser grained rocks as compared with the more quickly cooled, finer grained basalts.

Wager (1956) has defined successive stages of fractionation of a basic magma by plotting the iron ratios $\frac{Fe^{2}+ + Mn}{Fe^{2}+ + Mn + Mg}$ and the albite ratios $\frac{\text{(normative molecular albite)}}{\text{(Norm. molec. albite + anorthite)}}$ against each other.

The calculation of these ratios was carried out from the analysis of the Bridgewater type of basalt and, with these values as coödinates, a point is defined on the graphs of Wager, which lies amongst the tholeiitic basalts of the Hebridean province in the α-middle fractionation stage and removed from the plots of the olivine basalts. The average of six analyses of tholeriites plotting in this area is given by Wager (p. 231) and is reproduced above as Analysis 7. Except for a higher lime and lower magnesia content and a slightly lower silica percentage, this average is very similar to the analysis of the Bridgewater type.

It has been pointed out that a number of workers (e.g., Turner and Verhoogen, 1951, p. 181; Green and Poldervaart, 1955, p. 178) that there is a continuous series between the two magma-types rather than a distinct break. The evidence presented above confirms the conclusion of Edwards (1950) that the Brighton Basalts lie in this intermediate zone. However, it has been shown that these basalts have much stronger affinities with the tholeiitic rather than with the olivine-basalt magma-type.

VOLCANIC NECKS

In the same general area as the Brighton Basalts five volcanic necks have been found. Two of them are located in the Dromedary square, one at the north-western end of Goat Hill at 053468, the other 046436, west of Limekiln Creek. North-west of Maiden Early, at 157457, another neck occurs and the other two are located at 195392 in the Back Tea Tree Valley and at 183535, north-east of Butler's Hill. In plan, the necks are circular or sub-circular with diameters from 100 yards to 400 yards. They have been eroded down to the general level of their surroundings, except for the neck in the Back Tea Tree Valley, which rises as a cone-shaped hill to some 300 feet above the valley floor. In every case the necks are situated on, or very close to, a dolerite-sediment intrusive contact or a Tertiary fault, i.e., apparently along lines of weakness. Many of the dolerite intrusive contacts are massive and appear to be anything but lines of weakness. However, at some contacts, both the dolerite and sediments are strongly fractured and jointed.

The necks are considered to be Tertiary in age and belonging to the same volcanic period as the extensive basalts which crop out around Brighton.

The rocks found in the necks are dark-grey in colour, fine-grained and dense, and thin sections show them to vary considerably in composition. Basanites occur in the two vents of the Dromedary square, whereas the neck north-west of Maiden Early and that in the Back Tea Tree Valley are fine-grained olivine basalts. The neck north-east of Butler's Hill is composed of an extremely fine grained olivine basalt.

Thin sections 8423 and 8427, cut from specimens from the Goat Hill and Limekiln Creek necks respectively, consist of phenocrysts of olivine, which in 8427 are altered to and pseudomorphed by reddish-brown iddingsite, abundant very small monoclinic pyroxene prisms and iron ore granules set in a colourless, nearly isotropic base (see Plate III, Fig. 3). The olivine (and its pseudomorph) occurs as anhedral to euhedral phenocrysts averaging about 0.1 mm. in diameter and constitutes some 5% by volume of the thin sections. The pyroxene, comprising about 50% of the rocks, is present as pale-green prisms averaging approximately 0.01 mm. in length in 8423 and 0.035 mm. in 8427. Rare phenocrysts of pyroxene occur in both specimens, one of which in 8427 is 0.7 mm. in size. Iron ore, comprising some 10% of the thin sections, occurs as anhedral or well-formed crystals averaging about 0.005 mm. in diameter in 8423 and 0.02 mm. in 8427 and attains a maximum size of 0.04 mm. in the former and 0.2 mm. in the latter. The above constituents are set in a clear, colourless, low birefringent base, which has a refractive index less than that of balsam and is present to the extent of about 35% in 8423 and 25% in 8427. In both thin sections several per cent of colourless or yellow opal occurs in addition to chalcedony in 8423.

Spry (1955) described similar basanites from Sandy Bay and they also occur at New Norfolk. From the analysis made by Aurousseau (1926), Spry calculated the norm which shows a high orthoclase, albite and nepheline content and therefore considered that this indicates that the base is composed of a mixture of these minerals. The basanites occurring at Sandy Bay are considerably coarser grained and contain a lower proportion of iron ore than in the rocks found in the Dromedary square.

The volcanic neck north-west of Maiden Early is a dark-grey, dense and fine-grained rock containing fairly common phenocrysts which are mainly of olivine, although pyroxene and feldspar are also present. In thin section (8424) the rock contains phenocrysts of large euhedral to subhedral crystals of olivine, several subhedral pyroxenes, and plagioclase laths set in a fine-grained groundmass consisting of plagioclase laths, pyroxene granules and prisms of iron ore. The plagioclase laths, both large and small, are aligned to give a very distinct flow texture to the rock (Plate III, Fig. 4). The olivine, comprising some 10% of the rock, occurs as phenocrysts up to 2 mm. in size and granules down to 0.1 mm. or less in diameter are not uncommon. The $n\gamma$ was found to be 1.688, indicating that the olivine contains about 12% of the fayalite molecule which agrees with the very high optic angle of the mineral. The several phenocrysts of pyroxene, which appear to be augite, are pale-green in colour and occur up to 1.4 mm. in size. Within the groundmass abundant (40%) small granules and prisms of pale-yellow clinopyroxene occur, averaging about 0.025 mm. in diameter. Plagioclase feldspar, invariably in lath-shaped crystals, is present as phenocrysts as well as in the groundmass, there being all gradations in size. The phenocrysts are up to 0.7 mm. in length, but average around 0.3 mm., while those in the groundmass average about 0.05 mm. in size. The plagioclase, a labradorite, comprises about 40% of the rock, of which nearly one-quarter occours as phenocrysts. Iron ore makes up some 5% of the rock and is present as granules averaging 0.015 mm. in diameter which are commonly euhedral, although crystals occur up to 0.6 mm. in size and these are anhedral in form.

A plagioclase crystal 1.1 mm. long and 0.6 mm. in width occurs in thin section 8424, surrounded by a distinct corona up to 0.9 mm. in width and is shown in Plate III, Fig. 5. From the slightly off-centre X bisectrix figure the angle between the Y direction and the 010 cleavage was measured as 5°, indicating that the mineral is oligoclase. The corona surrounding the plagioclase consists of two zones, which have a sharp but irregular boundary between them, an inner one, 0.2 mm. to 0.35 mm. wide, which is extremely fine grained, and an outer, rather coarser grained zone 0.2 mm. to 0.5 mm. wide. The inner fine-grained zone consists of minute crystals which are light-grey in colour, have moderate relief and show upper first order to lower second order interference colours, suggesting that it is a pyoxene. The outer, relatively coarse-grained zone consists of crystals averaging between 0.05 mm. and 0.1 mm. in size but occur up to 0.4 mm. The granules are colourless; they have a high relief and strong birefringence with colours up to upper second order. The crystals are generally anhedral, but several well-formed prisms occur with cleavage, on which there is straight extinction, developed either parallel or transverse to the prisms. The properties indicate that the mineral is olivine. The contact between the feldspar and its corona is sharp and is step-like since it follows the two cleavages of the plagioclase. The inner zone is undoubtedly a replacement of the plagioclase since the cleavages and cracks can be readily traced into it. However, they do not pass into the outer zone. It is considered that the feldspar is a xenocryst caught up in the almost completely fluid magma as it ascended from below. Olivine had begun to crystallize, but plagioclase probably had not and, since the xenocryst was oligoclase it certainly must have been out of equilibrium with the magma. The physical conditions were such that the crystal, instead of being dissolved by the magma reacted with it and was replaced by what is possibly pyroxene, presumably by movement outward of soda and alumina and inwards of ferrous iron, lime and magnesia, by solid diffusion. The coarse outer zone of olivine granules was precipitated around the plagioclase and its corona, which together acted as a centre of crystallization. However, if the inner zone is in fact pyroxene and the outer one olivine, this is a reversal of the normal crystallization sequence, perhaps due to a local lowering in temperature in the vicinity of the xenocryst, followed by a re-establishment of equilibrium. Within the same thin section there is another similar occurrence, but in this case there is no feldspar core preserved. The rock is an olivine basalt and bears some resemblance to the Brighton Basalts. However, the fine grain size, the flow texture, the abundant phenocrysts of olivine and plagioclase are important differences.

In hand specimen the rock (8425) obtained from the volcanic neck north-east of Butler's Hill is dark-grey in colour, fine grained, dense, has common olivine phenocrysts, and contains several xenoliths. Some specimens have large angular olivine aggregates up to 20 mm. across. In thin section the rock is seen to consist of phenocrysts of olivine set in an extremely fine grained base of plagioclase laths, iron ore granules and much opaque indeterminable material. The olivine, which constitutes about 10% of the rock, is present as phenocrysts (up to 1 mm. in size) and microphenocrysts, though the former are not very common whereas the latter, averaging about 0.04 mm. in diameter, are abundant. The greater part of the rock (about 80%) consists of an almost opaque groundmass in which abundant iron ore granules 0.01 mm. or less in size occur in addition to laths of plagioclase averaging about 0.02 mm. in length. Amygdales, usually elongate in section and up to 2 mm. in size, contain calcite, chalcedony, opal and a zeolite, probably analcite and, in most cases, at least two of these minerals are associated in the one amygdale.

A roughly circular xenolith of medium-grained dolerite 3 mm. in diameter, occurs in the thin section completely surrounded by the fine-grained basait; the contact between it and the basalt is sharp. Also a plagioclase crystal 1.5 mm. long and 0.5 mm. in width is present surrounded by a corona, 0. mm. wide, of a similar type to that described above. However, the inner fine-grained zone is much narrower than that in specimen 8424 and passes into a coarser zone without a distinct break and there is no doubt that both zones are replacements of plagioclase in this case since the traces of twin lamellae of the plagioclase are clearly visible in the whole of the corona. The grey colour, the relief, the birefringence and the

prismatic form of some of the crystals suggests that the mineral constituting the corona is pyroxene. The plagioclase is an oligoclase with composition about Ab_{80}. A similar crystal occurs in the thin section which has been completely replaced by granules of pyroxene, no plagioclase remaining.

Several other large plagioclase crystals, also considered to be xenocrysts, occur in the thin section but these do not have coronas.

The rock is an olivine basalt which has been rapidly cooled. During its ascent from below the basalt picked up plagioclase crystals from the rocks up through which it passed and also included dolerite fragments as xenoliths. In some respects this rock is similar to 8424 but it is much finer grained and there is no pyroxene except perhaps in the corona of the plagioclase. However, both the rocks contain plagioclase xenocrysts with the same type of reaction rims suggesting that the magma in both cases passed through similar rock types as it ascended. It is possible that the plagioclase xenocrysts were derived from Triassic sediments since they commonly contain feldspar, but the presence of well-formed crystal faces on at least one of the crystals suggests that these xenocrysts were derived from crystalline rocks.

The volcanic neck in the Back Tea Tree Valley is composed of a dark, dense, very-fine-grained olivine basalt which in thin section is seen to be holocrystalline and porphyritic. Olivine, along with some pyroxene, occurs is phenocrysts which are set in a fine-grained groundmass consisting of pyroxene prisms, plagioclase laths and euhedral iron ore crystals. The plagioclase laths have a preferred orientation giving the rock a distinct flow texture. The olivine, making up about 10% of the rock, is present as fresh or slightly-altered phenocrysts which vary from euhedral to anhedral in form. Pyroxene, which is light-grey in colour and is all probably augite, occurs in two generations; those which are phenocrysts and those in the groundmass. The phenocrysts average between 0.1 mm. and 0.2 mm. in size, but occur up to 0.5 mm., whereas the well-formed prisms in the groundmass average about 0.06 mm. in length. The phenocrysts of pyroxene, which commonly are euhedral, constitute only about 2% of the rock, whereas the pyroxene in the groundmass comprises approximately 55% of the rock. The plagioclase is present as common (25%) colourless laths averaging 0.09 mm. in length. However, there are several crystals which reach 0.4 mm. in length. Iron ore occurs as relatively abundant (10%), often euhedral, granules averaging about 0.02 mm. in size and they are distributed evenly throughout the rock. The rock could have crystallized from a magma of very similar composition to that from which the Brighton Basalts were formed.

These five necks show great diversity in the textures developed within them, probably because of differences in composition and rate of cooling of the magma. Three of the necks appear to have a composition similar to that of the Brighton Basalts and they probably originated in the same magma chamber. There is no evidence to suggest that these necks are infilling vents from which the Brighton Basalts were extruded. The two necks occurring in the Dromedary square are basanites which are considerably more basic than the Brighton Basalts. Their position would allow them to be sources for the Brighton Basalts but the difference in composition does not support this hypothesis.

SUMMARY

A single flow of basalt, over 150 feet in thickness, was extruded in the Tertiary Period onto a topography which was rather similar to that of the present day. It is considered that the basalt flowed down the pre-existing Jordan River valley to the Derwent River valley, flooding back up the valleys of the Bagdad and Strathallern Rivulets. Except where the rivers have cut down into the basalt, the original surface of the flow, minus the upper scoriaceous layer, has been preserved. The cooling history of the basalt was complex, as shown by the unusually variable form of the contraction jointing pattern within the flow.

The basalt is an olivine bearing type which varies from an extremely fine-grained but porphyritic rock to a relatively coarse-grained rock with a dolerite texture, the rate of cooling being the controlling factor in the production of these textures. A decrease in the proportion of olivine down through the flow suggests that resorbtion by the magma of this mineral took place in the slower cooling parts of the lava. The magma is intermediate in composition between the olivine-type and the tholeiitic magma-type, but it has closer affinities to the latter.

Five volcanic necks occur in the area adjacent to the Brighton Basalts and these are believed to have been intruded during the same volcanic period.

ACKNOWLEDGMENTS

The author wishes to express his thanks to the staff of the Geology Department of the University of Tasmania for much helpful criticism and advice and, in particular, to Professor S. W. Carey and Mr. A. H. Spry.

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Plate I.

Fig. 1.—Well developed hexagonal columns in basalt at 142449 in a cliff beside the Bagdad Rivulet.

Fig. 2.—Fan-shaped collection of columns of basalt in a railway cutting at 134437.

Fig. 3.—"Syncline" of columns in basalt at 114399. Note the large vertical joint a little left of centre. At the right the columns are nearly vertical.

Fig. 4.—Closer view of the large vertical joint noted in the previous figure in the "axial plane" position of the "syncline".

Fig. 5.—Second "syncline" of columns at 115399 in a cliff beside the River Jordan. At mid left the columns are pointing directly towards the observer.

Plate II.

(*All photomicrographs taken under ordinary light.*)

Fig. 1.—Ouse type of basalt. Greyish granules of olivine with moderate relief and colourless plagioclase laths set in an abundant opaque base. X50.

Fig. 2.—Ouse Type; same as above but with phenocryst of olivine. Thin elongate microlites of pyroxene in the mesostasis at lower left. X50.

Fig. 3.—Bridgewater Type. Phenocryst of olivine, granules of pyroxene and plagioclase laths in an abundant opaque mesostasis. X30.

Fig. 4.—Pontville Type. Partially resorbed olivine intergrown as phenocrysts set in a groundmass of plagioclase laths and pyroxene intergrown subophitically and an intersertal, almost opaque, mesostasis. X30.

Fig. 5.—Midlands Tpe. Coarse ophitic basalt—colourless plagioclase laths included ophitically in large anhedral pyroxene crystals. X30.

Fig. 6.—Jordan Type. Basalt with an intergranular texture and consisting of plagioclase laths and granules of greyish pyroxene. At lower right an iron ore crystal; at centre dark-coloured opal, and at top centre brown (dark) intersertal mesostasis of small microlites embedded in glass. X65.

Plate III.

Fig. 1.—View from half a mile east of Summerville looking north up the Bagdad Rivulet valley across the well-preserved surface of the basalt.

Fig. 2.—View east up the Strathallern Rivulet valley from near Summerville across the flat surface of the basalt.

Fig. 3.—Basanite from volcanic neck at 040436, west of Limekiln Creek. Phenocrysts of olivine, pseudomorphed by iddingsite, set in a very fine grained groundmass of pyroxene prisms, iron ore granules and a colourless, nearly isotropic, base. Ordinary light, X65.

Fig. 4.—Olivine basalt from volcanic neck north-west of Maiden Early. Well developed flow texture due to alignment of plagioclase laths. Large phenocryst and a number of smaller crystals of olivine an phenocrysts of plagioclase set in a fine-grained groundmass, which is dark in the photomicrograph, consisting of plagioclase laths, pyroxene granules and prisms, and iron ore. Ordinary light, X65.

Fig. 5.—Xenocryst of plagioclase in same rock as previous figure. Colourless crystal of oligoclase surrounded by a fine-grained corona of pyroxene (dark in photomicrograph) followed by a coarser zone of granules of olivine. Ordinary light, X30.

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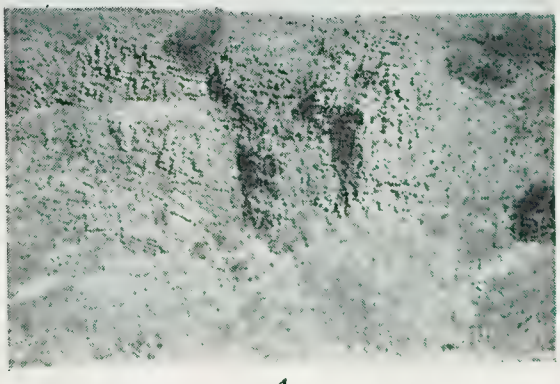

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PLATE I.

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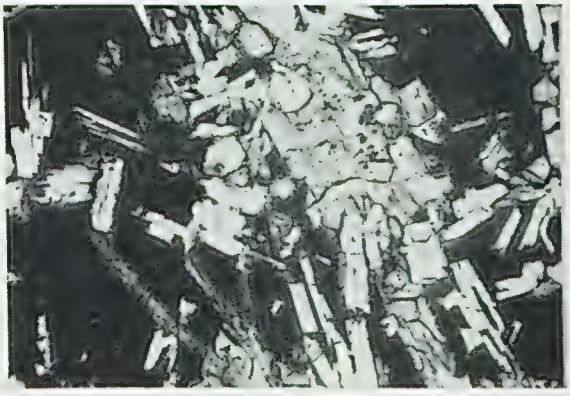

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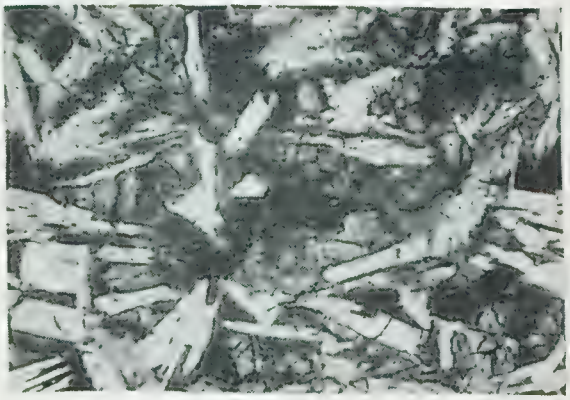

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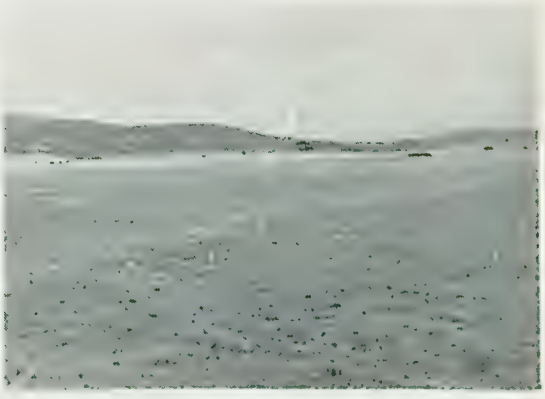

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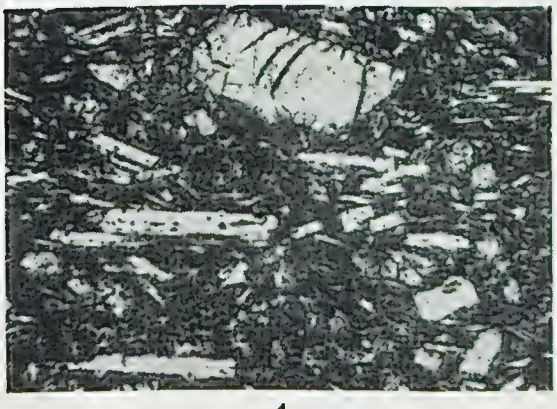

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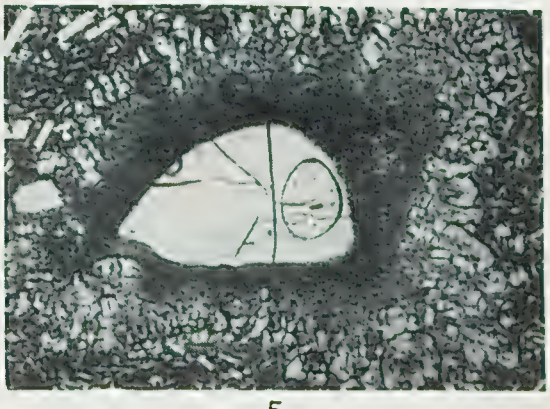

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PLATE III.

Papers and Proceedings of the Royal Society of Tasmania, Volume 93

THE SEDIMENTARY STRUCTURES OF THE UPPER SCAMANDER SEQUENCE AND THEIR SIGNIFICANCE

By

E. Williams

University of Tasmania

(With 2 Plates)

ABSTRACT

A number of sedimentary structures, which have previously not been described anywhere in Tasmania, are developed in the Scamander Slates and Quartzites, near Upper Scamander. These structures include markings made in muds that have been preserved as casts on the soles of graded sandstones and coarse-grained siltstones. It is well known that certain sole markings, such as flute casts, indicate the direction of the current responsible for their erosion and infilling. This is confirmed at Upper Scamander, for the distribution of the directions incated by these sole markings is similar to that obtained from an examination of current bedding developed in some sandstones and coarse-grained siltstones. A study of the rock types in the Upper Scamander sequence shows that the deposit "normal" to the area was of muds, whilst sands, coarse silts, and fragments of plants and a marine fauna were brought into the locality by turbidity currents, which probably originated to the south-west. The only evidence of life that existed at the site of deposition is the presence of worm-like grooves that were made on the surface of the muds.

INTRODUCTION

Near Upper Scamander, in the north-east of Tasmania, a well-exposed sequence of rocks occurs in road cuttings. During a recent visit to the road section, a number of sedimentary structures developed in the rocks were noted, which hitherto have not been reported anywhere in Tasmania. Apart from the general interest of recording these structures, which are the subject of many present-day researches in America and particularly Europe, a study of the road section has proved profitable in that a great deal more information has been obtained on the depositional history of these rocks. The results of the investigation point a way as to how the isolated sections of their correlates in north-east Tasmania may be made to yield far more information than they have to date.

THE UPPER SCAMANDER ROAD SECTION

The Upper Scamander road section is a type locality of the "Scamander Slates and Quarzites" (Walker, 1957). From the fossils recovered and from a general consideration, Walker expresses the belief that this formation ranges in age between the Middle Silurian and Middle Devonian and considers it to be a part of the Mathinna Group (Hills and Carey, 1949).

Because faults are present not all the road cuttings of the road section are considered, for parts of what has been mapped may be repeated in the remaining road cuttings. The section investigated extends 382 metres in the direction S 16° W along the road from the point of co-ordinates 892,000N-603,830E on the International Grid on Sheet No. 4 of the 4-mile state map of Tasmania. Although faults may occur where soil and rubble obscure parts of the outcrop in the mapped section, a comparison of the intact sequences has indicated no repetition.

The beds in the section mapped dip at 30°-50° in the direction W. 17°-32° N., and are very gently corrugated at a number of points. The axes of these tectonic corrugations trend at N 20° E to S 20° W, which agrees with the direction inferred by Walker (1957) for the regional folding, and their plunge, although difficult to assess, is considered to be about 8 degrees in the direction S 22° W. Thus, with the aid of a stereogram, all sedimentary structural directions have been rotated to the geographical horizontal about the fold axis direction, given by the corrugations, after corrections were made for the fold plunge.

The Scamander sequence exposed in the mapped road section is approximately 177 metres thick, and from a study of the compositions, textures and sedimentary structures the rocks can be divided into two distinct groups consisting of (1) mudstones and (2) sandstones and coarse-grained siltstones. Descriptions of the groups follow immediately, but the significance and the discussion of many of the various features developed in the rocks are given in the concluding section.

DESCRIPTION OF THE ROCK TYPES

1. Mudstones

Layers of mudstones occur in the section examined, and they vary from a few millimetres to 3.7 m. in thickness. Commonly, these mudstones, which break with a sub-conchoidal fracture, are banded and the bands, which are from 0.4 mm. to about 5 cm. in thickness, are coloured usually light to dark grey and occasionally purple or brown.

The mudstones are composed of varying proportions of mica laths, orientated parallel to the bedding planes, and sub-angular grains of quartz, which may be up to 0.02 mm. in size.

Sedimentary structures are lacking and no fossils were found.

2. Sandstones and Coarse-Grained Siltstones

These rock types are characterised by a number of features, noted below, which are entirely absent from the mudstones.

The layers of sandstone and coarse-grained siltstones, which vary from 2 cm. to approximately 3 m. in thickness, are usually massive. Lamination, when it occurs, is restricted to the sediment of the coarse siltstone grade.

By inspection with a hand-lens a number of layers are seen to be graded. Commonly, the gradation within a layer is from a median size grade of 0.25 mm. to 0.4 mm. at the base, to a median size grade of 0.03 mm. to 0.1 mm. at the top. However, examples occur of layers of sandstone or coarse siltstone grade only.

The sediments are poorly sorted, for even in the coarser horizons the particle size varies from that of the largest grain to clay grade. The grains are angular to sub-angular, and most of the larger ones are of quartz, but fragments of quartzite, chert, mica and occasionally feldspar occur. The fine material, of clay and fine silt grade, is of quartz grains and mica laths with subordinate amount of chlorite flakes. Many quartz particles show a little recrystallisation at their margins.

The poor sorting of the sediments (Plate 1 A) is significant, for it suggests that material as fine as clay size grade was deposited with the largest grains associated with it. In one layer occur chunks of dark grey mudstone, which are up to 16 cm. in length, and they are contorted in such a way as to suggest that they were not consolidated when they were deposited with grains of mainly coarse siltstone grade.

Fossils are not common, but Walker (1957) has recorded the recovery of a stunted marine fauna which included bryozoans, corals, brachiopods, and moulds of crinoid columnals. The fossils are often fragmentary, and their occurrence suggested to Walker that they indicated a place of burial and not of growth. Rare plant remains, which include the primitive plant *Hostimella* (?) described by Cookson (1936), have also been found.

A host of markings in muds have been preserved as casts on the soles of the sandstones and coarse siltstones. Walker (1957, p. 25) reported their occurrence and described them as "depositional rolls and corrugations", which he considered to have developed at right angles to the prevalent current direction. In recent years several types of sole marking have been described and a classification has been proposed (Kuenen, 1957). This classification and the terminology adopted by Kuenen is used in the following description of the markings occurring in the Upper Scamander road section.

Pre-current markings are rare and they are casts of meandering worm-like grooves (Plate 1 B). These occur on the soles of thin coarse-grained siltstone layers, and their absence from the soles of the sandstones is presumed to be due to their obliteration by later current erosion. The worm-like casts are the only evidence of life that existed on the depositional floor during the accumulation of the mudstones.

A profusion of current markings occurs. Flute casts, which are elongated parallel bulges, vary greatly from sole to sole both in size and shape. Usually the oblong bulges are bulbous at one end and flared at the other. They may be wide apart or crowded together to form numerous patterns. The flute casts vary in size from 12 cm. in breadth and 30 cm. in length to minute examples barely visible to the unaided eye. Photographs of some of the types observed are shown in Plates 1 and 2. Usually the same type occurs over a single sole, but exceptions are present and in one case flute casts of the usual shape are seen to develop in the direction of elongation into flat-topped parallel ridges. Only small and weak examples occur on the soles of the coarse-grained siltstone layers.

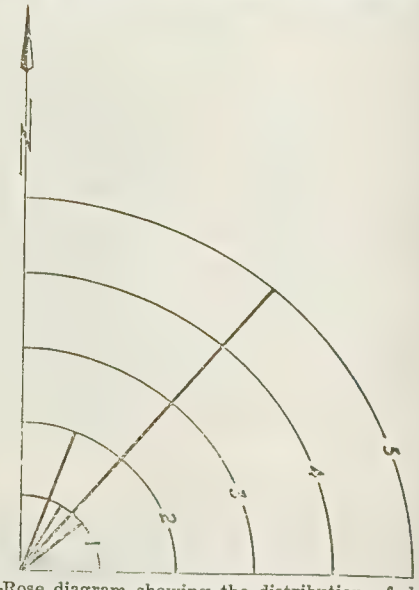

FIG. 1.—Rose diagram showing the distribution of down-current directions indicated by flute casts of nine horizons in the Upper Scamander road section.

It is well known that the direction from the bulbous to the flared end of a flute cast is in the direction of the current that was responsible for its erosion and infilling (Rich, 1950; Kuenen, 1953, 1957; and others). At Upper Scamander the direction of well-developed flute casts was determined for nine horizons, well spaced in the road section examined. These directions were then rotated to the horizontal about the regional fold axis by means of a stereogram, and plotted in the rose diagram of Fig. 1, which indicates that the currents responsible for the transportation and deposition of the sandstones and coarse-grained siltstones remained fairly constant in direction from the south-west throughout the time of accumulation of the sediments of the section mapped. On a sole of one coarse-grained siltstone, small and poorly-developed flute marks appear to indicate a current opposite in direction to those recorded

above, however this anomaly may result from the effect on the marks of the depositional phenomenon of load casting, described later.

Drag marks, which are long even ridges, are developed on some soles. Plate 2 C is the photograph of the cast of a drag mark some 3.4 cm. in breadth occurring on the sole of a sandstone bed. Many of the other marks are much smaller and are only just visible to the naked eye. In all cases the drag marks, which are characterised by a constancy of shape, size and direction, extend beyond the limit of the exposed sole. Their orientation, as is well known, tends to be in the current direction which was deduced by other features developed in adjacent layers of sandstone and coarse-grained siltstone.

All the pre-current and current sole markings have been exaggerated to varying degrees by load casting, which is a depositional feature. Load casting is the vertical adjustment resulting from the unequal loading of sands on the irregular surface of soft muds, and in the Upper Scamander road section structures caused by load casting are most apparent on the soles of the coarsest and thickest beds of sandstone. In many cases (Plate 2 D) load casting has produced overhanging edges to the flute marks and also "flame structures" (Walton, 1956, p. 267), which are irregular blade-like penetrations of mudstone into overlying sandstone.

Small-scale current bedding, with laminations rarely thicker than 0.5 mm., is sometimes developed in the top 10 cm. or so of a graded layer of sandstone, particularly where there is an upward gradation to a coarse siltstone, and in some layers of coarse-grained siltstone. The current bedding, which is generally of the type described as "festoon" by Pettijohn (1957, p. 169), occasionally shows the effect of current drag by the bending of the tops of the forset laminations in the direction of the current. Four current bedded horizons, which are well spaced along the mapped road section, have been examined, and the direction of current bedding has been calculated to within about 10 degrees by viewing the same lamination along at least three intersecting planes approximately perpendicular to the bedding plane. The directions so determined have been rotated about the regional fold axis to the horizontal by means of a stereogram. The direction of current bedding for the four horizons, is N 32°-52° W, which is similar to that obtained from the flute casts of soles, confirming the use of the latter in determining current direction.

Post-depositional sedimentary structures are rare, but gentle folding occurs in some sandstone layers. The layers themselves are not folded and are of uniform thickness throughout . Walker (1957, p. 26) considers the deformation to be due to slumping resulting from the slope of the depositional floor to the west. In the affected beds the folds are complete and are observed to flatten against the margins. In Plate 2 E the current bedded upper part of a sandstone layer has been gently folded and the flattening of the folds against the upper margin is clearly seen. Such folding would apear to be due to intrastratal flowage. Of significance is the coincidence in direction of the axes of these folds and the trend of regional folding, which suggests a tectonic control over their formation.

CONCLUSIONS

The mudstones have the characteristics of sediments formed by quiet deposition from dilute fluid suspensions, for they are of even grain size, the mica laths are invariably parallel to the bedding planes and they lack features which may indicate any other mode of transportation and deposition.

On the other hand, turbidity currents appear to be the only agents able to produce the combination of features found in the sandstones and coarse-grained siltstones at Upper Scamander. The significant features are poor sorting and grading (Kuenen and Migliorini, 1950; Kuenen, 1953), the profusion of current sole markings (Kuenen, 1957, pp. 232-3), and the fairly constant direction of the currents which transported and deposited these sediments (Kuenen, 1953, p. 1,045).

Current bedding and sole markings show that the turbidity currents came from an area to the southwest of Upper Scamander. The sediments of this source area must have been deposited in a sufficiently unstable attitude for masses of the material to slide down slope and become density currents by mixing with water. Under the influence of gravity these currents continued to travel down the sloping floor through clear water, with the coarser grades of their load of each current moving to their nose. The suspended material carried by the turbidity currents was usually of sand, silt, and fragments of plants and a marine fauna, but it is evident that there was a variation in the material available, for there are variations in the composition, and in the sorting of the sandstones and coarse siltstones (see Walker, 1957, p. 27).

When the turbidity currents reached a decrease in gradient they slowed and started depositing their load. The surface of the muds, over which the currents passed, was scoured and occasionally disturbed to such an extent that fragments of it became incorporated into the suspended material of the currents. Rarely, the surface of the muds was eroded only to a small degree, and worm-like grooves, the tracks of bottom living organisms, were not obliterated. Immediately behind the eroding nose of the current however, there was deposition, which began with the coarser grades of material and ended with the finer detritus of the tail.

Undoubtedly, not all the sediment carried by the currents was in suspension, for the drag marks found on some soles at Upper Scamander indicate traction. However, traction was of more importance during deposition from the tail of a current for the coarse silt grade material of the tops of some sandstone beds is current bedded, and examples are found of current laminations bent in the direction of the current.

Between the arrivals of turbidity currents at Upper Scamander fine silt and clay, which are the "normal" type of sediment to the area, were deposited. The only evidence of life that existed at the site of deposition is the presence of worm-like grooves that were made on the surface of the muds.

ACKNOWLEDGEMENTS.

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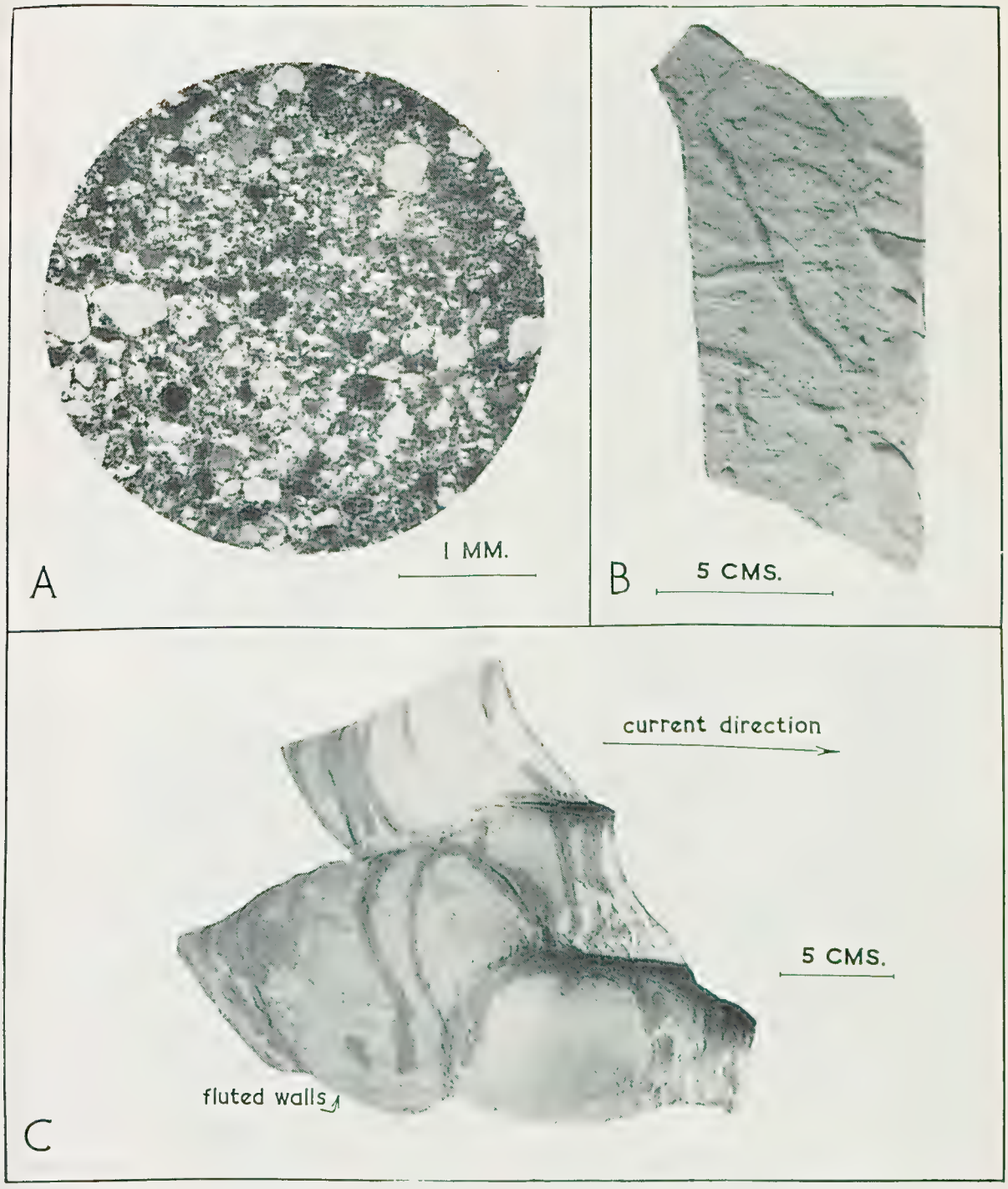

Plate 1.

A. Upper Scamander sandstone, crossed nicols. Sorting is poor.
B. Casts of meandering worm-like grooves on the soles of a thin coarse-grained siltstone.
C. Large flute casts with fluted walls.

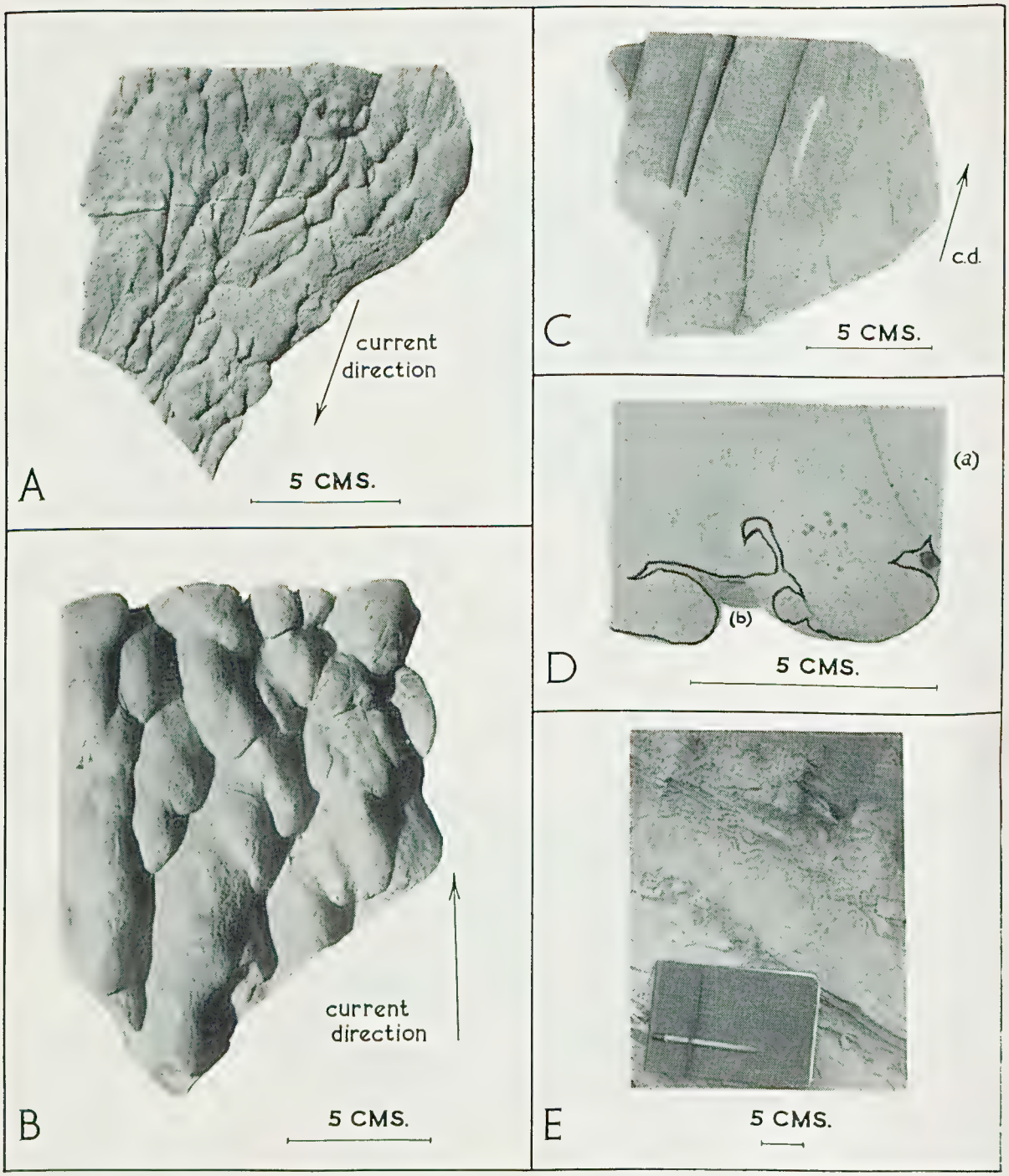

Plate 2.

A. Crowded flute casts.
B. Well developed flute casts.
C. Part of a cast of a drag mark.
D. Load casted flutings (plans shown in B) with overhanging walls and flame structures. Black line indicates boundary between sandstone (*a*) and mudsone (*b*). The photograph is of a section cut normal to bedding and current direction.
E. Folding produced by intrastratal flowage in a sandstone layer, current bedded at the top.

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INTERTIDAL BELT-FORMING SPECIES ON THE ROCKY COASTS OF NORTHERN CHILE

By

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(With 22 Text Figures and 2 Plates)

ABSTRACT

The zonation at four places in northern Chile is described. The general pattern of zonation throughout the Chilean coast is remarkably uniform with the important exception of Antofagasta where *Pyura chilensis* replaces algae in the Infralittoral fringe. The physical environment is described in some detail and the major intertidal features of Chile are compared with those of eastern Australia and South-West Africa to which they bear a close resemblance.

(1) INTRODUCTION

The only paper dealing with the intertidal ecology of restricted parts of the coast of Chile has been published earlier (Guiler, 1959). The present contribution describes the zonation at Iquique and Arica. These results are compared with each other and with the physical environment and the features of the Chilean coast as a whole is given. The relation of the fauna and flora of this coast to that of the Australian and South African coasts is shown. The present study does not include details of the distribution of the Chilean fauna and flora.

General observations on the geographic regions of Chile are made by Ekman (1953), who states that the southern limit of the tropical-subtropical fauna of the west coast of South America is very close to the Equator at either Punta Aguja (lat. 6° S.) or the Gulf of Guayaquil (3° S.). Ekman goes on to suggest that it is difficult to decide on location of the southern limit of the warm temperate fauna and suggests that there may not be two independent components—the warm temperate and the cold temperate. He later states that it is probable that there are two elements in the fauna and that the transition zone is at or near Chiloe Island (lat. 43° S.) since the cold water with a summer surface temperature of 8° C. commences thereabouts. Ekman further points out that the upwelling of cold water and the Humbolt Current are the two factors responsible for keeping the sea off the west coast of South America at a low temperature.

Oceanographic surveys have been made off the Chilean coast, Sverdrup (1931), Gunther (1936), and Deacon (1937) describing the results of these surveys, Deacon's work being concerned with only the extreme south of the continent. Schott (1935) gives much oceanographic and general information on the western coast of South America, while Murphy (1926, 1936) gives further oceanographic data as do Sverdrup, Johnson and Fleming (1942).

Mann (1954) describes the biogeographical regions of Chile, especially the northern parts. Koepcke and Koepcke (1951) give information on the ecological divisions of the Peruvian coast which has a direct bearing on the present study, and Petersen (1949) gives a small amount of ecological information in his study of the River Zuraumilla in Peru. However, none of these works makes any attempt to describe in detail the ecology of any one area or to compare the ecology of two different places.

During the summer of 1955 I was permitted to accompany an oceanographic expedition to the north of Chile. The expedition was organized by the Corporacion de Fomento in conjunction with the Estacion de Biologia Marina of the University of Chile. The expedition was transported on board the Chilean corvette *Papudo* and short stays were made at four of the northern ports.

The climate of the coast of Chile to the north of Coquimbo becomes very dry and, ultimately, in the provinces of Tarapaca and Atacama, results in the desert coast of northern Chile. The seaports are the only human settlements on this coast and it is nearly impossible, on account of inaccessibility, to make examination of the shore at places other than the ports. I have noted earlier (Guiler, 1959) that the Chileans are very fond of seafood and their gathering of animals and plants is restricted to the vicinity of the seaports by the same geographical factors as limit the collection of scientific material. Thus, some degree of human interference with the zonal organisms is to be expected, particularly with those species which are edible.

The places visited and described in this paper are Coquimbo (Lat. 29° 59′ S.), Antofagasta (Lat. 23° 40′ S.), Iquique (Lat. 20° 15′ S.), and Arica (Lat. 18° 20′ S.). I do not propose to detail the zonation and physical environment at these ports in this paper, but will do this in a later contribution. I have considered these ports together for the purpose of describing the zonation because the zonal pattern is so similar and also on account of the great amount of repetitive information that would be necessary if a description of each area were made the topic of a separate paper. Only the belt forming species are considered, the other ecologically significant species forming the topic of another paper.

(2) NOMENCLATURE

In the earlier paper describing the intertidal ecology of Chile I used the nomenclature put forward by Stephenson and Stephenson (1949) without any comment, but since this scheme has not been previously used in South America it seems desirable to have some discussion on the applicability of the scheme to Chilean coasts in general.

The Supralittoral Fringe

The limits of the Supralittoral Fringe furnish one of the major problems encountered in Chilean intertidal ecology. It has been suggested by the Stephensons that the upper limit of the Midlittoral, therefore the lower limit of the Supralittoral fringe, is the top of the barnacle belt. Further, following the Stephensons, the Supralittoral fringe is characterised by the presence of littorinid molluscs of one or more species, by *Ligias*, and by black encrusting Myxophyceae and lichens. Lewis (1955) points out that the upper limit of the midlittoral will vary locally, depending on the species, or in England—the genus, of barnacle found in that particular locality. However, he goes on to point out that, although the British Isles are of considerable local complexity, he does not advocate any alteration from the top of the barnacles as the demarcation line of the top of the Midlittoral. Prof. and Mrs. Stephenson, in a footnote to Lewis' paper point out that the barnacles, despite their drawbacks, are the best indicators available. They go further and point out that there is not expected to be a common level around a country, and, therefore the world, at which the barnacle belt cuts out. The work of Burrows *et al*, (1954) on Fair Isle shows that no constant level for any one zone can possibly exist.

At Montemar, near Valparaiso, there is a *Littorina* belt which lies within the top portion of the barnacle belt, that is to say, the *Littorina* belt forms a strip within the barnacle belt. By nature of the arguments expressed above, this means that the *Littorina* belt is part of the Midlittoral. Above this, there is a region of bare rock which is devoid of any apparent Myxophyceae and lichens. In certain other localities where there are cliffs, as on the coast adjacent to Montemar, there is a belt of lichens developed at very considerable heights, about 20 metres, above the water level but separated from the Midlittoral by a broad belt of bare rocks. This belt of lichens is usually very close to, if not continuous with, the terrestrial plants. Thus, in the Valparaiso area the Supralittoral fringe, as an ecological unit and neglecting small atypical patches, is either devoid of animal or plant life or else such life as exists is close to or almost a part of the terrestrial realm. The lichen belt must in many cases be considered as a part of the terrestrial rather than as intertidal in affinities.

How does it come about that there is neither a littorinid belt nor a lichen belt in the Supralittoral fringe or supralittoral zone? Part of the answer may be seen on Guano Island, where seabirds rest or breed in large, often fantastic, numbers. On a small island off the mouth of the Rio Aconcagua at Concon, to the north of Montemar, the barnacle belt has bare rock above it which is covered a short distance above the barnacles by guano deposits. The guano supports little plant life. This may in part be due to over-richness in nitrogen or to mechanical trampling by the birds. The effect of either of these factors will certainly be carried on to the bare rock below so that the lichens which might be expected to occur do not develop. Admittedly, the Guano Island is a very specialised habitat, but it is possible that smearing of the rocks with guano, always present on the Chilean coast, acts as an inhibitor to growth of lichens. It is noticeable on the desert coast in the north of Chile that there are no lichens whatsoever but the rocks are all liberally smeared with guano.

It was pointed out in an earlier paper (Guiler, 1959) that a lichen belt did not develop on the rocks at Montemar on account of their low height above sea level, i.e., all these rocks are in a bare supralittoral fringe.

The Midlittoral

This zone is easily recognised by the barnacle belt at its upper limit and by either algal turf or mussels at the lower limit. It should be noted that an entirely false impression of the zonation can be gained from an examination of the shore during the spring or early summer than when seasonal growths of algae of the genera *Scytosiphon*, *Iridaea* and *Porphyra* cover considerable areas of the shore, both in the horizontal and vertical planes. Indeed, *Porphyra* extends into the Supralittoral fringe in early summer at Montemar.

All of the Midlittoral can be considered as a Balanoid zone, since it is populated over most of its vertical range by barnacles of one species or another. In all places the dominant species on the upper part of the zone are barnacles and there is usually a very numerous barnacle population on the mussels found in the lower part of the zone. However, in places where there is an algal turf, few barnacles are found. The important point is that all of this belt is exposed at low water.

The Infralittoral Fringe

Throughout all of the Chilean coast the Infralittoral fringe is nearly always dominated and can be recognised by the presence of one or both of the two large algae *Durvillea* and *Lessonia*. A notable exception to this is at Antofagasta, where these algae are replaced by the ascidian, *Pyura*. This feature will be discussed later in this paper. The upper limit of the fringe is, of course, very variable in the level at which it occurs. Wave action is the principle factor controlling the height at which the zone occurs on the shores (Guiler, 1959).

There is no reason for abandoning the Midlittoral and Infralittoral fringe as regions on the shore since both are easily recognisable as such and this terminology is obviously suited to the conditions. However, due to the special conditions of rainfall operating on the Chilean coast, the Supralittoral fringe, as defined, was found to occur in separate patches, the usual condition being that the littorines occur on the top of the barnacle belt. It must be borne in mind that all my shore

examinations were carried out in the summer so that an examination carried out in the winter may find different conditions brought about by a seasonal migration of the littorines. At present, the only conclusion which may be drawn is that the Supralittoral fringe is often absent in the summer on parts of the Chilean coast.

The different tidal levels are designated following Chapman's (1938) nomenclature and the terms zone and belt follow their definitions in Guiler (1953).

(3) THE PHYSICAL ENVIRONMENT

(a) *Currents.*

The coast of Chile, although of great length and extending, at it does, well into the tropics, is nevertheless washed by cool waters. Cold surface waters extend closer to the Equator on the west coast of South America than on any other southern continental mass. The coastal current system is first distinguished in about 38° S. and it moves slowly northward along the coasts of Chile and Peru to 4° S. where is sets W.N.W. and flows past the Galapagos Islands, ultimately becoming lost in the south equatorial drift. The current is primarily confined to the coastal belt of Chile and Peru where it diverges from the shore, but it extends for almost 10° of longitude into the Pacific just south of the equator.

A result of the divergence from the shore is an upwelling of phosphate-rich cold water (see below).

The current system has two sources of water. In the southern portion the water of the coastal current is sub-Antarctic in origin and flows north as a result of the west wind drift hitting the South American land mass. This cold oceanic water, as it moves north, is reinforced by upwellings of Antarctic water and becomes the Peru Coastal Current. According to Gunther, the southernmost limit of these upwellings changes in position, varying with the season, but, when the *William Scoresby* was on the coast, the upwellings were strong at Copiapo and extended to Cape Carranza (Lat. 35° 40′ S.). Gunther states that the extreme southern limit can be placed at 40-41° S. and he found that the current flowed faster inshore (10-12 miles per day) than 100 miles offshore (3½ miles per day). There is some evidence of a seasonal variation in the rate of flow in the charts published by the Meteorological Office (1938), but Barlow (1938) found the rate of flow constant throughout the year, though with a maximum in August.

It happens from time to time that the trade winds, normally southerly along the west coast of South America, fail due to the southerly movement of a low pressure belt normally situated to the north of the equator. The trades are replaced by a north wind bringing with it a flow of hot equatorial water of low salinity along the coasts of Peru and Chile. This hot water, known as El Nino, kills fish and plankton in immeasurable quantities and must cause a tremendous mortality among intertidal organisms. El Nino is most strong in Peru, where it usually occurs in the period January to March. The northerly winds bring rain to the normally dry coast, e.g., in 1925 the amount of rain that fell was ten times the total that fell over the preceding 10 years (Murphy, 1936). It is interesting to note that this total would only be 70 mm. The Nino traditionally occurs strongly every seven years and even more strongly on a thirty-four year cycle (Murphy, loc. cit.), though Sverdrup, Johnson and Fleming (1942) do not find any periodicity. The Nino, when it does occur, is a narrow current only two or three miles in width. It is usually recognised that the Nino effect reaches as far as Arica (18° 20′ S.) in northern Chile, though I have been told by Chileans that the Nino may extend as far south as Talcahuano. Insufficient sea temperature records are available as yet to check this view but there may be some confusion between the Nino effects and certain large scale natural mortalities, such as have occurred amongst the squids in southern Chile. However, Murphy (1926) records an abnormal temperature of 17.7° C. in Lat. 34° 42′ S. in March, 1925, which is ascribed to an abnormally strong Nino. The description of the effects of a Nino given by Murphy in this paper is very full and gives an excellent picture of the catastrophic conditions which prevail during Nino years. Mears (1954) suggests that catastrophes occur due to local warming in the absence of upwellings.

There is another hot current which runs off the Peruvian coast from April to July and it is usually accompanied by a change in colour of the surface water. This effect, known as aguaje, apparently is confined to Peru and has no effect on Chilean intertidal life.

(b) *Winds.*

The winds immediately offshore on the Chilean coast fall into two major regions. There is a southern region, south of 38° S., which is characterised by westerly winds of the " Roaring Forties ". This region shifts north and south during the period of Austral winter and summer respectively. To the north of this there is the major part of the Chilean coast as far north as 18° S. on the Peruvian frontier, which is dominated by the southerly winds. These are sea surface winds and usually do not extend above 5,000 or 6,000 feet and so are dominated by the Andean Cordillera. This influence extends almost to the Peruvian coast where the winds become the South-East Trades and blow away from the coast (see Mossman, 1909; and Gunther, 1936).

Gunther (loc. cit.) notes that the winds actually blowing on the Chilean and Peruvian coasts and the land immediately behind the coast are very weak and consequently least certain in direction while the strength of the winds increases with the distance offshore.

The south-westerly sea breeze plays a very considerable part in the influence of wave action on the Chilean coast. It has been noted at Montemar that a sea breeze usually appears in summer at some time in the late morning or early afternoon and blows, at times appreciably severe, for most of the afternoon. The sea is whipped up into short sharp waves which are superimposed upon the normal south-westerly oceanic swell prevalent on the coast, and render collecting virtually impossible during most of the

day. On one occasion at Montemar I estimated that a sea breeze reached a Beaufort Scale velocity of Force 5. Bowman (1916) describes the sea breeze as entering deeply into human affairs since it can inhibit or even stop loading of ships at the open roadstead ports of northern Chile and Peru, e.g., Arica, Callao, &c. The breeze loses strength during the afternoon and usually has died out by 1700 hours. The sea breeze is purely a coastal phenomenon and does not extend far out to sea.

Winter gales from the N.W. are often very severe and could have a very appreciable local affect on the intertidal flora and fauna. These gales caused havoc in the fleets of sailing ships on the coast during the boom years of the nitrate trade.

(*c*) *Upwellings.*

Upwellings of cold phosphate-rich water take place at various places on the Chilean coast, largely as a result of the wind diverging from the shore. It is usual to use the normal surface temperature of the latitude compared to the observed temperature of the sea as the indicator of upwelling and its amount. Gunther compares the inshore surface temperatures with the temperature at 150 metres and also with the mean surface temperatures at the 100° W. meridian. He found evidence of upwelling at Cape Carranza (Lat. 35° 40′ S.), Pichidangui (Lat. 32° 12′ S.), Caldera (Lat. 27° 10′ S.), Antofagasta (Lat. 23° 29′ S.), Arica (Lat. 18° 28′ S.), and the Peruvian ports of San Juan (Lat 15° 25′ S.), Callao (Lat. 12° 15′ S.), and Guanape Is., Lobos Is., Punta Agujo, Cabo Blanco and Santa Elena, all on the Peruvian coast.

The actual location of the upwelling is variable according to the wind strength and distant winds apparently are as important as local breezes (Gunther, 1936). The upwelling is a shallow phenomenon, the water coming from a depth less than 380 metres.

The upwelling, combined with the current system, has, as we shall see later, a profound effect on the intertidal life of Chile and Peru. The water off these coasts is cold, phosphate-rich and reasonably uniform. Murphy (1936) notes that plankton samples taken along two-thirds of the Peruvian coast are identical in their species composition.

(*d*) *Salinity.*

The North Chilean coast is characterised by no large rivers which would have any effect upon the salinity of the sea over any appreciable distance from the mouth of the river. The greatest changes in salinity occur in the north of the coast when the Nino is flowing and at places where upwellings sporadically take place. Gunther (loc. cit.) shows the salinity in the coast as in Fig. 1.

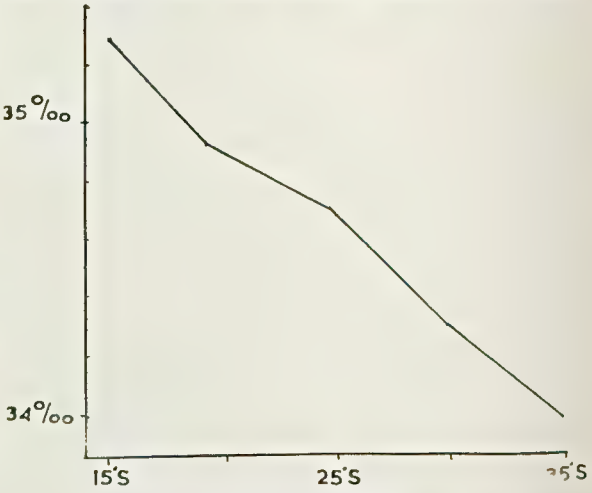

Fig. 1. Salinity gradient off the Chilean Coast (based on Gunther, 1936).

(*e*) *Sea Temperatures* (Table 1)

The Mean Monthly Sea Temperatures (in °C.) recorded at Antofagasta and Arica.

(From U.S. Coast and Geodetic Survey (1952).

Period	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Antofagasta.													
1946-51	20.7	20.1	18.8	17.3	16.2	15.5	14.9	15.0	15.7	16.5	17.9	19.3	17.3
Maximum ...	25.0	22.8	21.2	19.4	17.8	17.8	17.2	17.8	17.8	18.9	20.0	27.2	
Minimum	17.8	17.8	16.7	15.6	15.0	13.9	13.3	13.3	13.9	15.0	16.1	17.2	
Arica.													
1951	19.2	18.7	18.2	17.6	18.0	17.8	17.8	17.6	17.2	18.0	18.1	18.05	

Table 1A

Mean Monthly Sea Temperatures in Degrees Centigrade at Five Chilean Ports (from U.S. Coast and Geodetic Survey, 1952).

Port	Latitude	January	February	March	April	May	June	July	August	September	October	November	December	Years of Records	Temp. Range
Arica	18° 20′	19.2	18.7	18.2	17.6	18.0	17.8	17.8	17.6	17,2	18.0	18.1	18.05	1	2.0
Antofagasta ..	23° 40′	20.7	20.1	18.8	17.3	16.2	15.5	14.9	15.0	15.7	16.5	17.9	19.3	6	5.8
Caldera	27° 10′	18.2	17.3	17.0	16.2	15.9	14.5	14.9	14.5	15.0	15.6	16.5	16.2	1	3.7
Valparaiso	33° 15′	15.8	15.5	14.7	14.1	13.3	12.6	12.6	12.4	12.7	13.1	13.6	15.0	8	3.4
Talcahuano	36° 40′	12.8	12.9	12.6	12.0	12.3	11.8	11.0	10.9	11.5	12.1	12.6	13.1	8	2.2

Figure 2 shows the isotherms for the Chilean and southern Peruvian coasts following Gunther (1936).

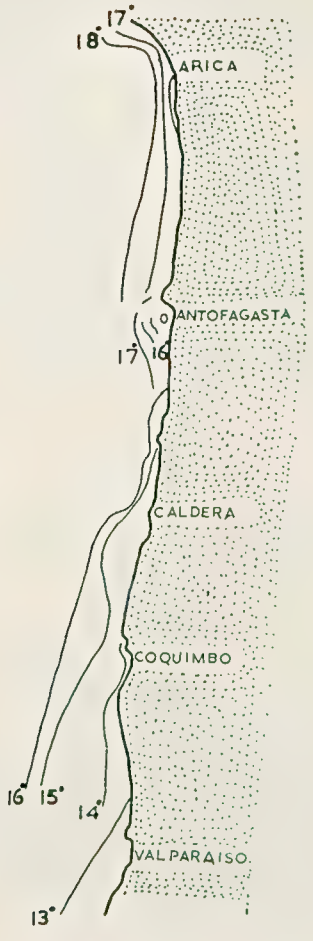

FIG. 2. Isotherms for the Chilean coast for May-June, 1931 (after Gunther, 1936).

Table 1 shows the mean monthly surface temperatures at some Chilean ports as measured by the U.S. Coast and Geodetic Survey. Some discussion of this table is desirable since there are some deviations in temperature conditions to be observed. Firstly, it is to be noted that September is the month of coldest water at Arica. Admittedly, this is based solely on one year's records but this is at least some information. The warmest sea temperature for the year throughout the coast is January, except at Talcahuano where, surprisingly, December is the month of highest sea temperatures. This feature may be variable from year to year since the breakdown of the averages for Montemar (see Guiler, 1959) shows a maximum in either February or January of subsequent years.

The most interesting information to come from these figures is the very large annual range of sea temperature at Antofagasta (5.8° C.). The sea at Antofagasta is warmer in the summer than at Arica, over five degrees of latitude nearer the Equator, and the winter minimum monthly mean temperature is only slightly above that of Caldera, four degrees further to the south. It is unfortunate that there are no temperature records made at ports nearer to Antofagasta than Arica or Caldera since much light would be thrown on the distribution of the isotherms in relation to seasonal changes.

The figures for Antofagasta as given in Table 1, particularly those relating to summer conditions, do not correspond with the isotherms as given by either Gunther or Sverdrup, Johnson and Fleming (1942). The correspondence between the winter isotherms of Gunther and the figures in Table 1 is fairly close at the ports of Talcahuano, Valparaiso, Caldera and Arica, and even at Antofagasta there is a fair degree of correspondence. Antofagasta is one of the ports off which there is a major site of upwelling (see above) which explains the low winter temperatures.

Gunther notes (p. 191) that a southerly current runs close to the coast, seldom more than two or three miles in width, especially in places where water movement, especially upwelling, is conspicuous. He goes on to postulate two wedges of warm, highly saline water lying off central and southern Peru respectively. It is not possible that this wedge of warm water, moving south with the trade wind system in summer, reaches as far as Antofagasta. Dr. H. N. Carruthers suggested (personal communication) that the warm waters at Antofagasta are due to local meteorological effects, probably brought about by an offshore wind causing an upwelling inshore of warmer water.

Leipper (1955) showed that the fluctuation in coastal temperatures in shallow water are caused not only by internal waves but also by the periodic migration of patches of cold water over an irregular bottom due to variations in the velocity of the tidal current. These conclusions, based upon observations made at La Jolla, California, would be particularly applicable to the Chilean coast, where meteorological effects are known to have a profound effect upon the behaviour of the Peru Coastal Current. The variations caused by these factors would be strengthened by the cold upwellings giving rise to sources of cold water at varying distances off shore.

It was noted earlier (Guiler, 1959) that the mean monthly sea temperatures at Antofagasta are closer to the absolute minimum temperatures than to the absolute maximum temperatures. This shows the steady cool influence of the Peru Coastal Current. The greatest temperature observed at Antofagasta was 27.2° C. in December, which is 7.9° C. above the monthly maximum temperature.

It is clear that the temperatures in the sea off the Chilean coast require much greater continuous study than has been carried out in the past and the isotherms as shown at present may only represent a temporary stage in an alternating pattern. Figure 3 shows summer coastal isotherms as calculated from the U.S. Coast and Geodetic Survey results and this picture differs very sharply from those of Gunther showing Antofagasta to have warmer water than the surrounding areas.

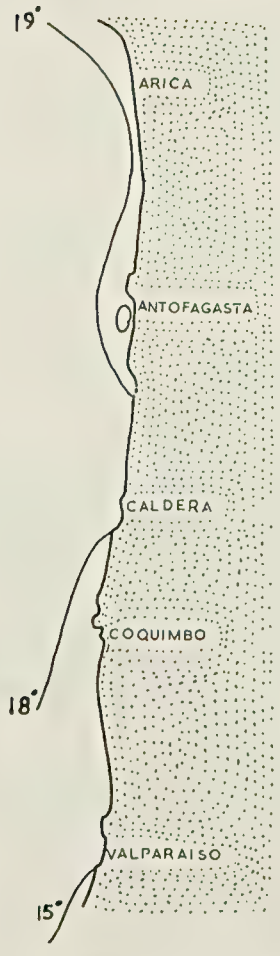

FIG. 3. Suggested summer isotherms for the Chilean Coast.

The sea temperature gradient for the Chilean coast is shown on Figure 4. In this figure, which is based on the January and August mean temperatures, the higher summer temperature at Antofagasta is especially to be noted. The figure emphasises slightly that Antofagasta has apparently a slightly lower winter temperature than might be expected. The sea temperature at Arica is 0.1° C. lower in September and the Talcahuano summer temperature is 0.1° C. higher in February than those shown on the figure.

Gunther notes that the wind causes appreciable changes in the surface temperatures, his Table III shows the distance the isotherms are encountered offshore under differing wind conditions. The least wind force gives the greatest rise in sea temperature and easterly winds give a cooling tendency in the sea, since this causes increased upwelling.

Gunther found that the sea temperature changes seasonally at a rate of .23° C. per week. At Antofagasta, using the figures in Table 1, the rate of temperature change from January to July is .24° C. per week, which corresponds closely with the figure derived by Gunther, while for the 12 months the rate of change is .21° C. per week. The most rapid change takes place during March, April, November and December, when the change is 0.35° C. per week. During July and August the rate of change is only 0.01° C. per week.

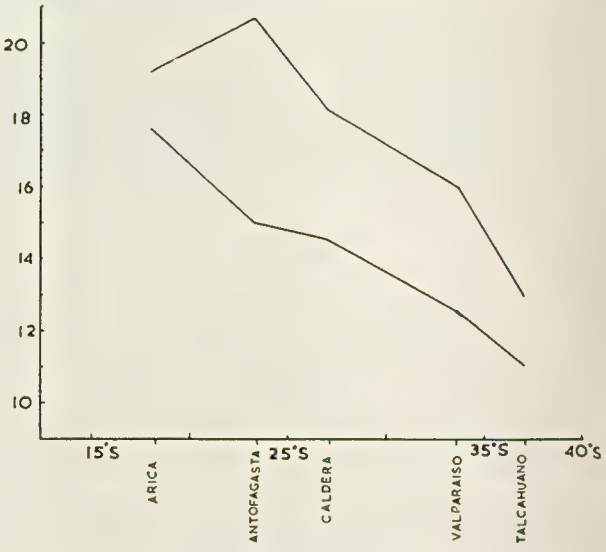

FIG. 4. Summer and winter sea temperature gradients for the Chilean Coast.

(f) Air Temperatures (Table 2)

The summer (January) and winter (July) temperature gradients on the Chilean coast are shown in Figure 5, which was constructed from the data supplied by the Oficina Meteorologica de Chile. Neither of the gradients are smooth, both showing irregularity in the curve at Antofagasta, Coquimbo, Valparaiso and Concepcion.

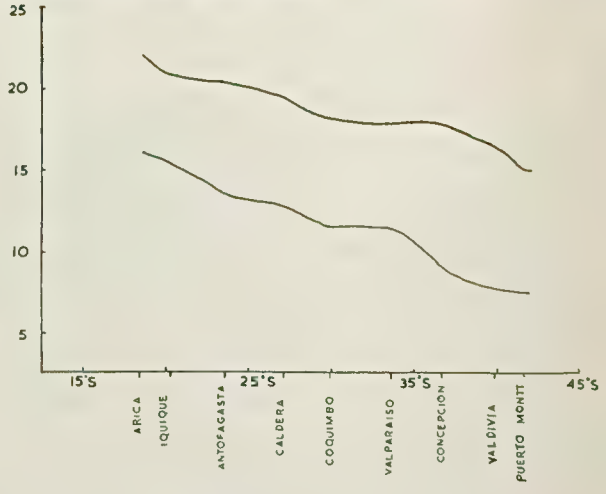

FIG. 5. Summer and winter air temperature gradients for the Chilean Coast.

The summer temperature at Concepcion is warmer than on adjoining parts of the coast, while the winter temperatures are cooler, but at Valparaiso both the summer and winter temperatures are higher than might be expected, being similar in many respects to those prevailing at Coquimbo, four degrees to the north.

The irregularity at Antofagasta is due to a lowering of the winter temperature to a figure somewhat below expectation.

The most important factor which emerges from figure 5 is the small difference in the temperatures at Arica and Valparaiso. In the summer this difference is only 4° C. and in the winter 5° C., this occurring in a distance of 15° of latitude.

Schott (1935) calculated the difference between the temperature of the air and that of the sea, subtracting the air temperature from that of the sea. The resultant figures, the "negative Anomalie" or "positive Anomalie" can be graphed using "Isanomalen" or lines of equal departure.

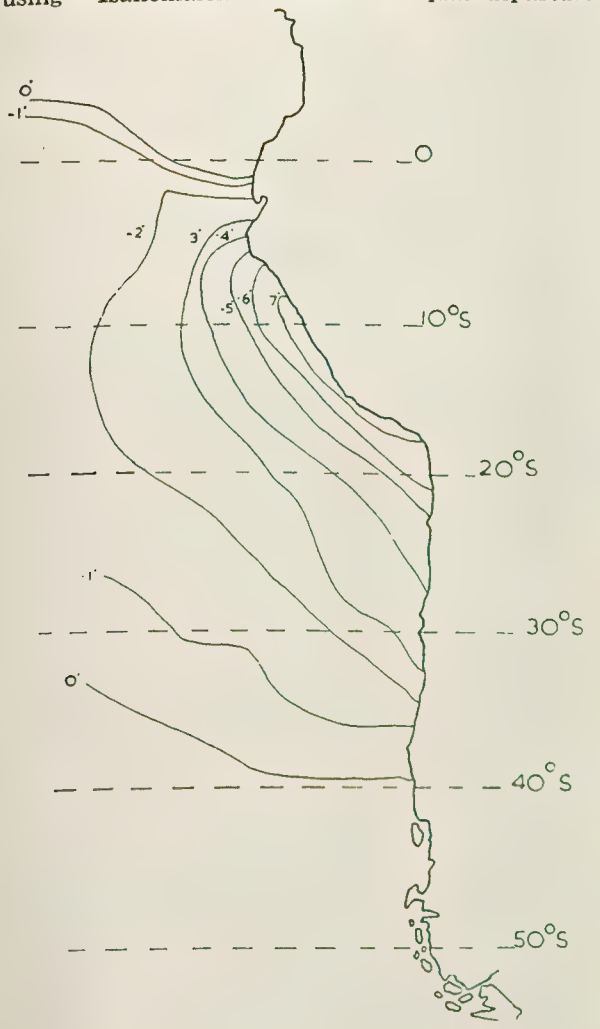

Fig. 6. Summer isanomalous lines for the Chilean Coast.

The isanomalous lines for the Chilean coast are shown in Figures 6 and 7. The line of zero departure, i.e., where the air and sea temperatures are the same, starts on the Chilean coast about Lat. 39° S., near Tolten, and runs more or less due west out to sea. To the south of Tolten there is a positive "Anomalie" of 1° C. as far as the Taitao Peninsula (46° S.) followed by a region extending to Cape Horn (54° S.) where the sea is 2° C. warmer than the air.

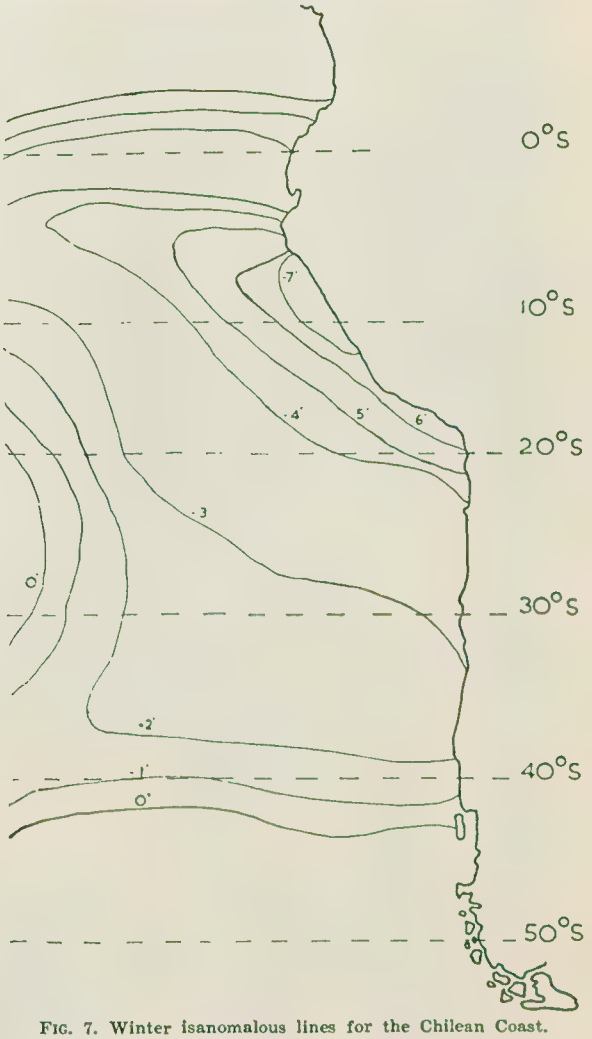

Fig. 7. Winter isanomalous lines for the Chilean Coast.

All of the rest of the Chilean coast to the north of Tolten, that is the part with which this survey is concerned, lies in a region of negative departure, the sea being cooler than the air. The maximum departure is reached in Southern Peru and Arica where it reaches 7° C. off Callao in Peru. The departure reaches 8° C. in August, which is by far the largest departure in the oceans of the Southern Hemisphere. On the eastern coast of South America at the same latitude as Arica there is a positive departure of 1° C. (Schott, 1926).

(*g*) *Rainfall* (Table 2)

The Mean Monthly Rainfall (in mm) at four Northern Chilean ports from data supplied by The Oficina Meteorologica de Chile.

Station	Period of Records	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Coquimbo	1911-49	0.1	1.6	0.2	2.2	20.4	36.1	22.8	16.9	4.6	3.2	0.9	0.8	109.6
Antofagasta	1911-49	....	....	....	0.3	0.1	0.7	2.4	1.2	1.0	0.8	0.2	....	7.7
Iquique	1911-49	0.1	....	....	....	....	0.2	0.7	0.7	0.3	0.1	....	....	2.1
Arica	1911-49	0.3	....	....	....	....	0.1	0.1	0.1	....	....	....	0.1	0.7

Murphy (1936) notes that there is a great, often startling biotic change associated with a negative departure and he cites the Galapagos Islands as an example of this. Chiloë Island, a region regarded as being the boundary between the cold temperate and warm temperate faunas of western South America, lies close to the line of zero departure.

It can be deduced from the above that the intertidal region is kept cool by the effects of a cool breeze blowing off a sea which is considerably colder than the air temperature.

It should be noted that monthly sea and air temperature charts are given by the Air Ministry (1950). These charts have been consulted in this section of the present paper but have not been reproduced since the scale on which the maps are drawn is too small to show the isotherms in sufficient detail for my purposes.

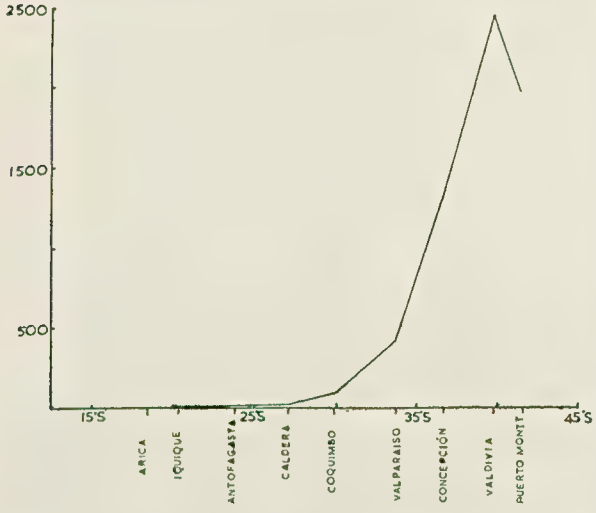

Fig. 8. Rainfall gradient on the Chilean Coast.

The rainfall on the Chilean coast is seasonal, most of the annual precipitation taking place during the months of May-August. However, in the parts of Chile lying to the north of Coquimbo the rainfall is extremely sporadic and, although there is a mean monthly rainfall quoted in weather reports, this figure is of little significance since rain may not fall for fifteen years or more and then a relative deluge may occur. Coquimbo is sufficiently far south to show evidence of the Mediterranean type of climate which is experienced by much of the central coastline of Chile, 90% of the precipitation taking place between May and August inclusive. Antofagasta, Iquique and Arica are very much desert ports as regards the amount of rain which they experience.

However, the rainfall figures shown in Table 2, while giving an impression of the rain encountered, do not give a true picture of the monthly rainfall at Antofagasta, Iquique and Arica since there may be no rain at these ports for many years until a sudden deluge occurs. Murphy (1926) gives a vivid description of the catastrophic effect of such a deluge upon parts of the Peruvian coast where similar conditions prevail. Rainfall over the northern Chilean and southern Peruvian coasts is therefore practically unknown and its absence can be important to intertidal organisms.

Under conditions of heavy wave exposure such as exist along the west coast of South America there is always some spray being blown inland. This spray falls on and above the intertidal region where it leaves a salty residue. Thus, hypersalinity is a feature of the Supralittoral to Midlittoral zones of this coast. Relief from this condition is obtained at high tides or during storms. A toleration of high salinities and a resistance to dessication are the prime requisites of life for intertidal organisms living at high tidal levels on a coast experiencing extremely low rainfall. To this may be added a resistance to the products of decay since there may occur little washing away of dead organisms.

The presence of spray in itself will act as a factor modifying the effect of dessication and it has been shown that mists and fogs help intertidal organisms to exist at levels above the height at which they are usually found (Burrows *et al*, 1954). Fogs and mists are frequent on the Chilean desert coast and must be considered as important elements in reducing the dessication factor.

The rainfall gradient on the Chilean coast is shown on Figure 8, which was constructed from the data given by the Oficina Meteorologica de Chile. The rainfall increases very sharply from Coquimbo (Lat 30° S.), reaching a maximum at Valdivia (39° 50′ S.).

The relative humidity curve for the Chilean coast is shown in Figure 9, based upon data supplied by the Oficina Meteorologica de Chile.

(*h*) *Relative Humidity* (Table 3)

The Mean Monthly Relative Humidity at four Chilean ports from data supplied by the Oficina Meteor ologica de Chile.

Station	Period of Records	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
		%	%	%	%	%	%	%	%	%	%	%	%	%
Coquimbo	1911-46	77	78	80	81	82	80	81	80	80	79	77	77	80
Antofagasta	1919-40	73	74	75	75	75	74	76	76	75	74	71	72	74
Iquique	1911-45	79	79	83	80	81	80	79	79	79	79	78	78	80
Arica	1911-46	72	71	73	75	76	76	78	78	78	76	74	72	75

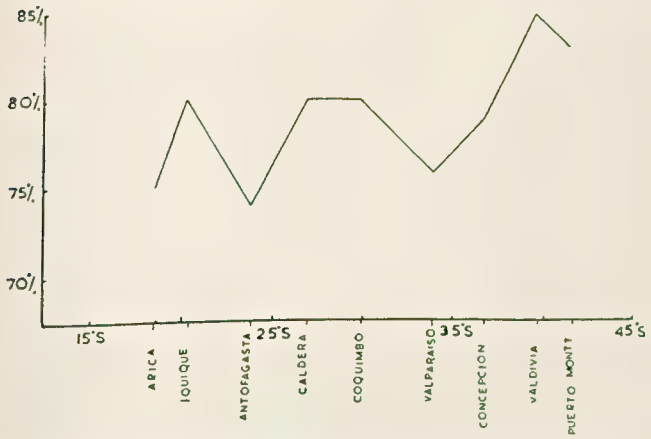

FIG. 9. Relative humidity on the Chilean Coast.

It is most noticeable that the southern areas of Valdivia and Puerto Montt, where the temperature is lowest, have the highest relative humidity. However, the converse does not hold true though Arica and Antofagasta do have low relative humidities whereas Iquique has a much higher figure.

Comparison of Figures 4, 5, 8, and 9 shows that, in general the climate, going from south to north becomes progressively warmer, very much drier, with slightly warmer seas and slightly less relative humidity. However, Antofagasta forms an important exception to the general rule in that Gunther found the sea colder in winter than might be expected. The temperatures taken by the U.S. Coast and Geodetic Survey do not fully reflect this feature but do show that the summer temperatures are greater than might be expected. The records at Antofagasta have been taken for six years while those at Caldera and Arica, to the south and north respectively, have only been taken for one year.

It should be noted that when considered in relation to the latitude, the seas are colder than in any other part of the ocean masses.

(*i*) *Fogs and Mists*

Mention has been made earlier of the mists and fogs which are persistently found on this coast. These mists, reaching fog dimensions at times, arise adiabatically out at sea in the area of the Peru Current and are blown inland by the wind. Bowman (1916) wrote that the mist or clouds hung at between 2,000 and 4,000 feet on the coast, rising during the day and settling almost to sea level at night. These mists are not always present on the coast, though reference to the Air Ministry charts (1950) shows that mists are very persistent, except during the months of January and June. Their effect on the shore is to cut down insolation and, combined with the on-shore breeze blowing off seas up to 7° C. cooler than the air temperature, make the temperature lower than otherwise might occur.

During the afternoon the coastal belt is cooled down by a sea breeze which may reach Force 5 or more at times. The sea breeze causes short, sharp seas and is of considerable importance in wetting the intertidal region. It is not possible to determine in any satisfactory fashion the actual wetting power of the waves but at times on the exposed places the spray reaches the highest point of animal or plant colonisation. This is an important factor since the wetting may occur at the period of low water and maximum insolation.

(*j*) *Tides*

The amplitude of the tides plays an important role in controlling the distribution of the belt forming organisms. Brattstrom and Dahl (1951) give details of the amplitude of the tides at various ports on the Chilean coast.

The average amplitude was calculated for those ports for which annual tide tables are prepared annually by the Chilean Navy (1954) and is the average of all the tides during the year, but tide tables are not prepared by the Navy for all Chilean ports. The amplitude of the tides decreases towards the north of Chile, with a probable narrowing of the vertical width of the intertidal zones, which would result in a relative increase in the importance of the spray factor.

TABLE 4

Tidal Amplitudes at various Chilean ports, partly after Brattström and Dahl (1951).

	Lat. °S.	Spring Tidal Amplitude in metres.	Average Amplitude in metres.
Arica	18° 20′	1.40	....
Iquique	20° 15′	1.50	....
Tocopilla	22° 06′	1.20	....
Antofagasta	23° 40′	1.60	0.78
Coquimbo	29° 55′	1.50	....
Valparaiso	33° 15′	1.82	0.92
San Antonio ..	33° 35′	1.25	....
Talcahuano	36° 40′	1.80	....
Lota	73°	1.90	. .

It has been shown that the highest tides in the summer occur during the midday-midnight period (Guiler, 1959) and this, combined with the cool air from the sea and mists, together with a not inconsiderable spray, must cause a considerable reduction in the effect of insolation on intertidal forms. Similarly, it was found that the tidal behaviour in the winter tended to protect intertidal organisms from the full effect of cold nights, since the " higher high " tides occur during the midnight-midday period.

Figures 10 to 21 show monthly exposure curves at Antofagasta.

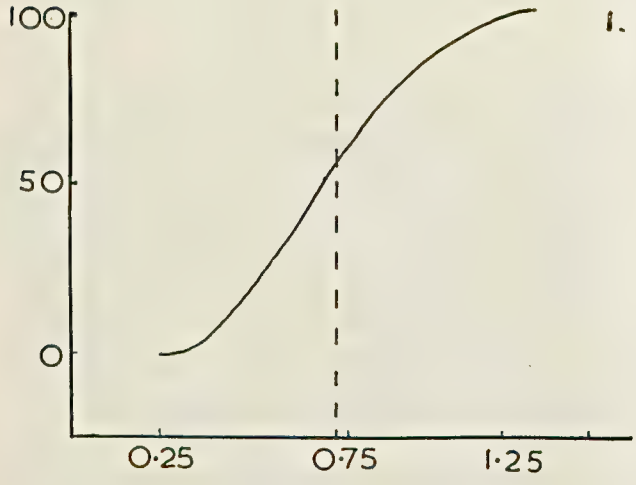

Fig. 10.

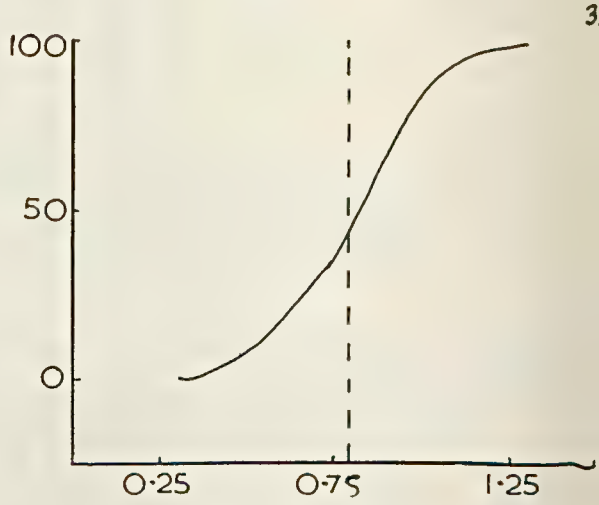

Fig. 12.

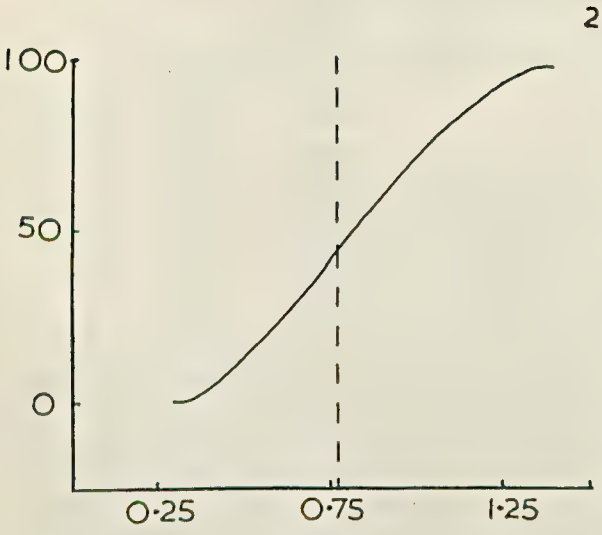

Fig. 11.

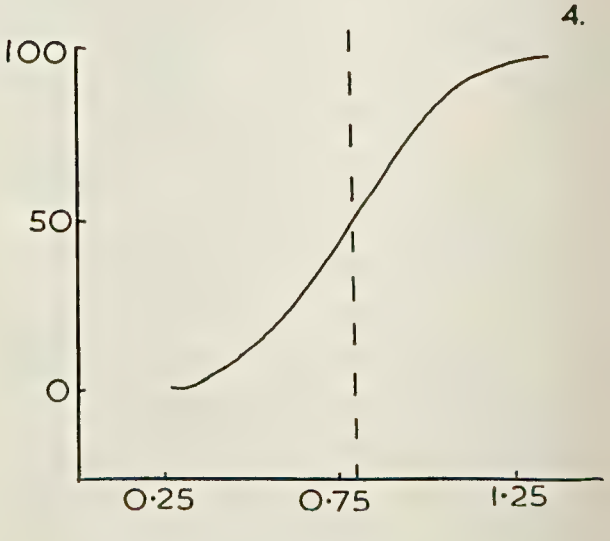

Fig. 13.

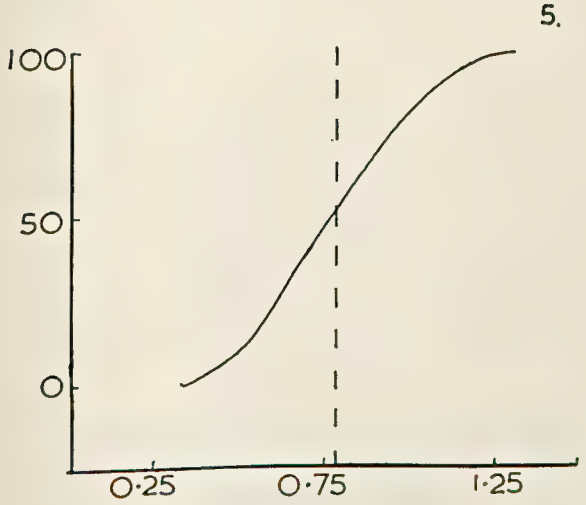

Fig. 14.

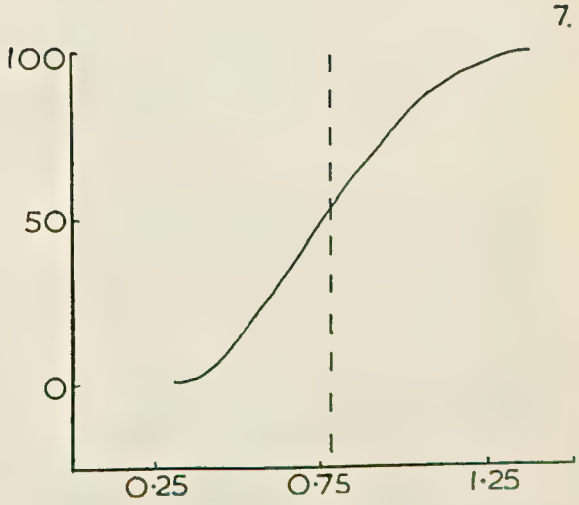

Fig. 16.

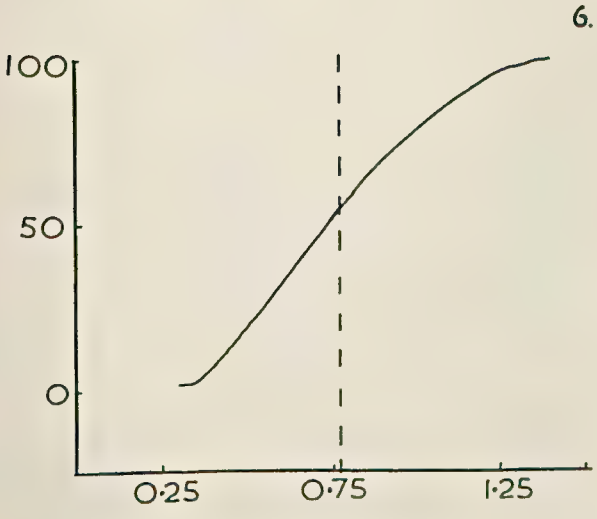

Fig. 15.

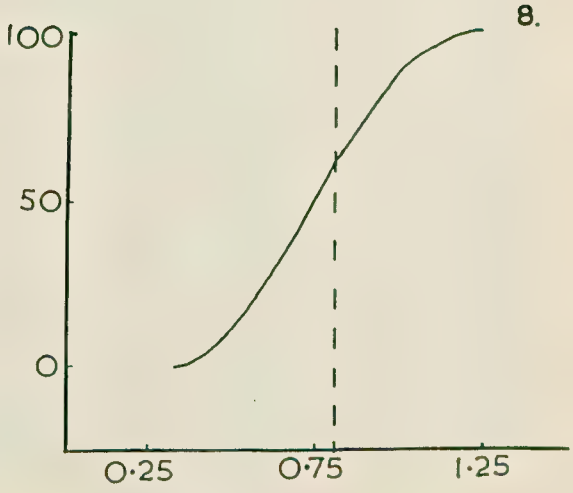

Fig. 17.

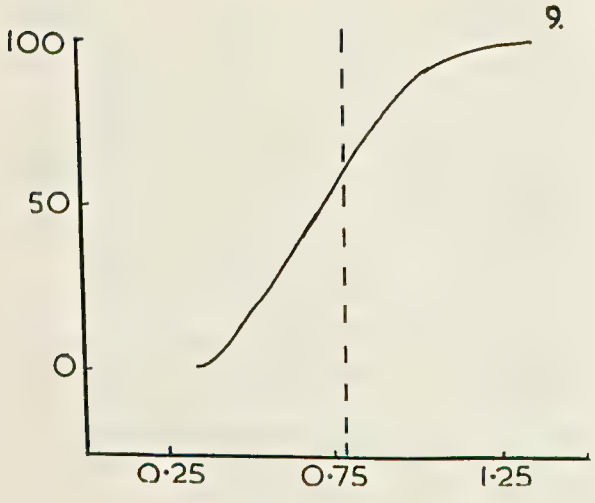

FIG. 18.

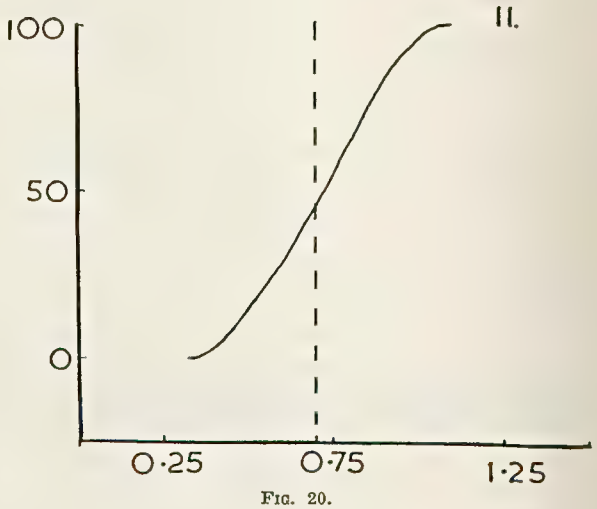

FIG. 20.

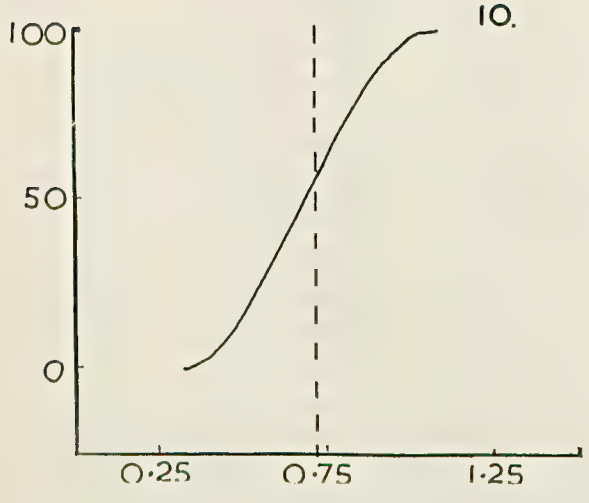

FIG. 19.

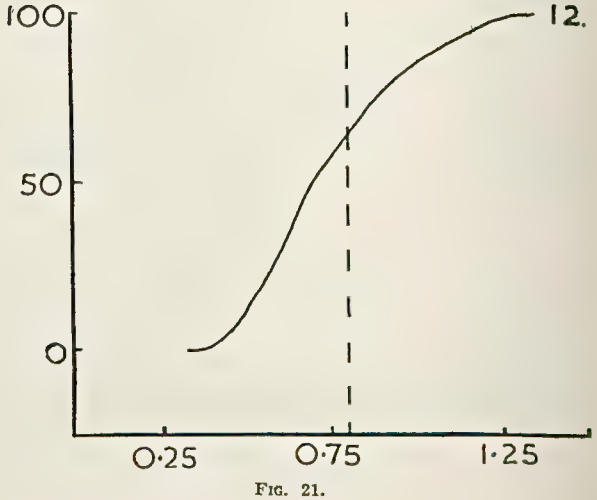

FIG. 21.

Monthly tidal exposure curves for Antofagasta were calculated using the same methods as those described for Montemar (Figs. 10-21). Examination of these figures shows that the exposure at any one level on the shore increases gradually from January to August when it decreases again. This means that intertidal organisms are exposed for longer periods of the day to the extremes of summer heat and winter cold.

(k) Wave Action

The prevailing wind on the central and northern coasts is the trade, here southerly, with strong sea breezes in the afternoon in the summer. The prevailing swell is S.-S.W. in direction. Most of the coastline with which this paper is concerned is exposed to the full effect of the wind and swell with the result that the wave action is among the most continuous in the world. I discussed the effect of the waves in the first paper of this series and it is not necessary to repeat those earlier remarks. It is necessary to re-emphasise that wave action and associated spray are the dominant factors controlling the width of the intertidal bands on exposed coasts such as this.

There are no bays to the north of Chiloë Island which can be described as sheltered. On the central and northern parts of the Chilean coast sheltered conditions can be said to be non-existent. There are a few semi-sheltered positions, e.g., in the Talcahuano, Concepcion and Tocopilla areas but these are comparatively exposed when compared to other sheltered localities in the world.

The wave action is very much more powerful and persistent than encountered on British coasts, though some of the very exposed parts of the west of Ireland and the Western Isles of Scotland may measure up to Chilean standards of intensity. The severity of the wave action on the east coast of Australia, especially in New South Wales and on the west coast of Tasmania, would be similar in strength to that encountered in Chile. I have no experience of New Zealand wave action nor of South African.

To sum up the physical features of the Chilean coast we find that the coast is bathed by cold to cool waters, refreshed by cold upwellings caused by the cool trade winds blowing along the line of the coast. The air temperatures are cool, especially in the north, due to the winds being cooled over the sea; mists are prevalent, again especially in the north and the general climatic factors and tidal behaviour combine in such a fashion as to protect the intertidal organisms from the full effect of the sun. The rainfall is seasonal over most of the coast but on the desert coast it is sufficiently infrequent in occurrence for its absence to be a major ecological factor to intertidal organisms. The wave action is intense and is considered to be the major factor, over-ruling the tides, in determining the width of the intertidal zones.

Although there is little range in the climatic factors and the sea temperatures are fairly steady throughout the year, the coastal forms certainly as far South as Arica, if not much further, are liable to suffer virtual extinction from the hot Nino current and heavy rains which occur periodically.

(4) THE ZONAL PATTERN

The zonation was examined at each place visited and will be described below separately for each port.

(a) Coquimbo

Coquimbo was visited on 20th February, 1955.

The area on which the zonation was examined is Punto Tortuga, to the north of the harbour area of Coquimbo. The particular area examined lies on the north-east side of the port and is not exposed to the full effects of the south-westerly swell. The substratum is a coarse sandstone.

The zonation is—

Bare rock.
Chthamalus cirratus Darwin.
Chthamalus cirratus + *Littorina peruviana* D'Orb.
Chthamalus cirratus + *Endarachne binghamiae* J. Ag.
Chthamalus cirratus + *Balanus flosculus* Darwin.
Balanus psittacus Darwin + *Corallina chilensis* Decaisne
Lessonia nigrescens Bory + *Lithothamnia* + *Acanthopleura echinata* (Barnes).

As at Montemar, the most notable feature of the shore is the absence of any belt above that dominated by barnacles. The *Littorina* belt, so usual in many parts of the world above the barnacles, forms a discontinuous sub-belt within the upper part of the barnacle belt.

The barnacle belt is very well developed, both as regards the vertical height of the band and numbers of individuals inhabiting it. It is noteworthy that cirripedes form the principal zone-forming group on the shore at this place.

Chthamalus cirratus is dominant over most of the shore but in the lower part of the barnacle belt it is joined by *Balanus flosculus* and these two species together form a very dense covering to the rocks.

Chthamalus cirratus favours places where there is wave action with some spray. This species is not found in large numbers in places where it is exposed to strong sunlight. *Balanus flosculus* prefers similar situations but, being found at a lower tide level, its distribution is less influenced by the direction of the sunlight.

In the lower part of the *Chthamalus* belt there is a strip formed by the alga *Endarachne binghamiae* J. Ag. The weed forms a sub-belt just below the middle of the *Chthamalus* belt, but this strip is very thin, rarely being more than 5 cm. in vertical height. The weed favours places where there is some wave action and spray.

The large and prominent *Balanus psittacus* is very obvious at the top of the Infralittoral fringe. It occurs only in places where there is wave action. *Balanus psittacus* particularly favours the edges of rocks which are beside deep water and which always have waves breaking on them. In this type of situation *Balanus psittacus* extends down the seaward face of the rock into the Infralittoral. Also found in the Infralittoral fringe with these barnacles are *Balanus laevis laevis* and *Balanus flosculus*, though these species do not necessarily live in places with continuous broken water.

The nereid worm *Pseudonereis gallapagensis* Kinberg is common on the shore living amongst scattered clusters of the mussel *Brachidontes purpuratus* Lam. and also in dead shells of *Chthamalus*. The edible mussel *Mytilus chorus* Molina is common, forming clusters in slightly sheltered positions, e.g., just inside the entrances to gulleys. Another species of mussel, *Brachidontes granulatus* Hanley, is not nearly as common but it is found in similar situations. In some restricted areas, where the wave exposure factor is suitable, both or either of these species may form sheets over gently-sloping surfaces.

Limpets and siphonarians are common in the *Chthamalus* belt. *Siphonaria* (*Pachysiphonaria*) *laeviuscula* Sowerby and *S.* (*Pachysiphonaria*) *lessoni* (Blainville) are both common as are the limpets *Acmaea viridula* (Lam.) and *A. araucana* D'Orbigny. Of these species *S. lessoni* is the most common. The mussels *Brachidontes purpuratus* and *Mytilus chorus* are both found in ponds on the shore, but in the case of *M. chorus*, the individuals so found are small in size. The prawn *Rhynchocinetes typus* H.M.Edw., is frequently found in these ponds as are *Siphonaria lessoni* and the chitons, *Chiton cumingsi* Frembly and *C. latus* Sav. *Siphonaria lessoni* is usually found living on rocks but is frequently found on the bottom of ponds. Below the stones found in either ponds or lying loose on the floors of gulleys and clefts are the Porcellanid crabs *Petrolisthes tuberculatus* (Guerin) and *Petrolisthes angulosus* (Guerin). Of these two species *Petrolisthes tuberculatus* is the less common. *Paraxanthus barbiger* (Poepping) and *Pilumnoides perlatus* (Poepping) are both found in the same semicryptic habitat but *Pilumnoides perlatus* is also found among the "roots" of the holdfast of *Lessonia nigrescens* Bory. *Tegula atra* (Lesson) and *Turbo niger* (Wood) were found at the upper limit of the Infralittoral fringe in regions of submaximal exposure.

The Infralittoral fringe, in which it was impossibel to collect satisfactorily due to the high tide at the time of my stay in Coquimbo, is characterised by *Lithothamnia* and two other species, depending on the amount of wave exposure experienced. Near the port of Coquimbo, where the wave action is reduced, *Lessonia* becomes rarer and ultimately absent. It is not replaced by any other species but the belt is thus left dominated by the *Lithothamnia* and *Acanthopleura echinata*. It must not be assumed that the lessening of wave action has suited the growth of *Lithothamnia*. It is more true to say that the reduction of the wave action has eliminated *Lessonia* leaving the other species.

There is no similar reduction in the number of *Acanthopleura echinata*, this species being found sparsely distributed throughout the whole area. Although sparsely distributed this chiton is very conspicuous by its size.

Other species found in the Lessonia belt are the urchin *Tetrapygus niger* (Molina) and the thaid *Thais chocolata* (Duclos) which are very common in clefts and deep ponds. The latter species is not as common as at Montemar nor is it as large. Another species which is smaller than the Montemar specimens is the "loco" *Concholepas concholepas* (Bruguiere). The large *Balanus psitticus* is also found in the *Lessonia* belt.

(*b*) *Antofagasta*

Antofagasta wis visited on 22nd February and 2nd March, 1955.

The zonation was examined at Playa Blanca opposite the Artillery Barracks beyond the southern end of the town on the road to the Automobile Club.

The zonation:—

Bare rock.
Chthamalus cirratus.
Chthamalus cirratus + *Littorina peruviana.*
Chthamalus cirratus + *Enteromorpha* sp.
Chthamalus cirratus + *Colpomenia sinuosa* (Roth) Derby & Sol.
Pyura chilensis Molina + *Corallina chilensis* Decaisne.
Pyura chilensis.
Lithothamnion sp.

The shore topography in this area has considerable bearing on the type of zonation. The rocks are all of a shale which gently dips away from the sea forming a wide erosion platform which is swept by the usually heavy surf. During the period of both visits to Antofagasta the shore was covered with white foam which acts as a very efficient protection from the sun. The foam filled the clefts and gulleys in the rocks and covered all the shore from the top of the barnacle belt down, except in places where the waves were actually breaking across the rock.

It has been noted above that the less rainfall means that a high toleration of the products of animal and plant decay must be possessed by organisms living at high levels on the shore. During both visits to Antofagasta the dominant feature of the shore was the excessively strong smell of decay. When I first encountered the smell I assumed that is was sewage but it later became apparent that the stench arose from thousands of decaying ascidians which were lying at or above high-water mark.

The ascidians covered several miles of beach (Plate 1) and their stench carried up to a quarter of a mile inland. Undoubtedly the cause of death of the ascidians was the strong summer sun. All the ponds had one or more decaying ascidians in them and a scum, as well as the foam mentioned earlier, covered these ponds which the wave action did not disturb.

The barnacle belt which is formed by *Chthamalus cirratus* has a considerable vertical range. On the upper part of the shore the barnacle belt is characterised by a strip of the littorine, *L. peruviana*. The lower part of this belt has a number of siphonarians, *S. lessoni*, living in it but nowhere do these gastropods form a belt. The Siphonarians within this belt are often found in sun-sheltered places such as clefts or shaded sides of rocks, though they may also occur frequently in considerable numbers on rocks which, although exposed to the sun, also are wave-washed. The interaction of spray and sun towards gastropods was noted at Montemar (Guiler, 1959) where the distribution of the *Littorinas* was partly controlled by these two factors.

It is interesting on this shore to see that algae play such a large part in the zonation. Immediately below the *Littorina peruviana* belt a species of *Enteromorpha* becomes very common and forms a sub-belt within the barnacle belt. In turn the *Enteromorpha* yields place to *Colpomenia sinuosa* var. *lacunosa* Taylor.

Siphonaria lessoni is common in the barnacle belt together with *Acmaea viridula*. There are no large limpets of the genera *Patella*, *Cellana* and *Nacella*.

The barnacle belt is replaced by the Pyura-Corallina belt. *Pyura chilensis* forms a dense covering to the rocks (Plate 1) and *Corallina chilensis* Decaisne utilises the ascidian as a sub-stratum. This belt is not very wide and is followed by a belt dominated by *Pyura*, though it usually has *Ulva lactuca* L. living on it. *Ulva* is generally found on the upper surface of the ascidians, i.e., around the oral and atrial siphons. The ascidians are very densely packed together, forming a continuous carpet on the rocks. On the death of an ascidian the test remains intact for some time and decay of the internal organs continues within the test causing a white sticky substance to ooze out of the apertures. This is probably the material from which the foam on the shore is formed.

Some words are necessary about the *Pyura* belt, especially since the presence of such a belt is a feature not experienced in the northern hemisphere. This ascidian possesses a very tough, almost cartilaginous test, the integument of which is strengthened by included sand grains. The individuals are closely united into a coalesced mass which offers a very strong resistance to wave action, and the space between the ascidians and the rock offers a sheltered habitat for more delicate organisms.

The *Pyura* belt, where it is together with *Corallina* and/or *Ulva*, forms a habitat for numerous individuals of smaller species. The porcellanid *Petrolisthes angulosus* (Guerin) is very numerous in clefts between the tests of the ascidians as well as living between their "roots" and the rock. This crab is also very common under stones in gulleys and ponds. The crab, *Acanthocyclus gayii* H.M.Edw. & Lucas, is found in the same type of habitat in the ascidian beds and along with *Petrolisthes angulosus* is also found under small beds of the mussel, *Brachidontes purpuratus*.

The very large barnacle *Balanus psittacus* occurs at the lowest part of the *Pyura* belt, especially in places where the platform ends. These barnacles are not conspicuous since they may be confused with *Pyura*, especially as they are about the same size and both *Balanus psittacus* and *Pyura* are frequently covered with algae. These algae mainly fall into two species, an *Ectocarpus* sp. and *Halopteris hordacia* (Harv.) Sauv.

The "loco" *Concholepas concholepas*, is fairly common in the Infralittoral fringe as are the chitons *Enoplochiton niger* and *Acanthopleura echinata* and the large fissurellid *F. costata* Lesson. *Fissurella limbata* Sowerby is found not only in the Infralittoral fringe but also on the rock under the *Pyura* beds.

The algal flora of gulleys consists of *Halopteris hordacea*, *Glossophora kunthii* (C. Ag.) J. Ag., *Ulva lactuca*, *Coralina chilensis*, *Colpomenia sinuosa* *Ectocarpus* spp., *Chaetomorpha linum* (Muller) Kutz., and *Padina triastromatica* Ler.

Below stones in the clefts and gulleys there is a numerous fauna, in addition to the crabs mentioned above. *Pseudonereis gallapagensis* Kinberg, *Lumbrinereis tetraura* and *Cirriformia* sp. all live in the shale below the stones. The under surface of the stones are frequently covered by *Spirorbis* sp. and a small, strongly radiate barnacle *Balanus flosculus*.

Examination of shell beds revealed numerous *Balanus laevis laevis* Darwin but no living specimens could be found. The same source provided numerous carapaces of the crab *Cancer polyodon* Poepping but as in the case of *Balanus laevis laevis*, no living individuals could be found.

The lowest belt on the shore which represents the extreme lowest part of the Infralittoral fringe is occupied by *Lithothamnion* spp., and the large chitons *Acanthopleura echinata* and *Enoplochiton niger*.

(c) *Iquique*

Iquique was visited on 25th February, 1955. The examination of the shore was carried out first at Primeros Rocas, about four kilometres south of the town and then at Playa Blanca, several kilometres to the south of the town and then at Playa Blanca, several kilometres further to the south near Punta Gruesa. Playa Blanca is the more important of these two localities.

Zonation at Playa Blanca:—

Littorina peruviana.
Chthamalus cirratus.
Chthamalus cirratus + *Balanus laevis lacvis.*
Colpomenia sinuosa + *Brachidontes purpuratus.*
Colpomenia sinuosa + *Mytilus chorus.*
Corallina chilensis Decaisne + *Tegula atra.*
Lithothamnion sp. + *Lessonia nigrescens.*

At Playa Blanca the zonation is difficult to determine because the soft shale beds forming the substratum dip towards the sea leaving a series of shallow gulleys running more or less parallel to the shoreline. The shore reefs are protected from full wave action by reefs just offshore. These gullies are continuously inundated by waves coming up to them, i.e., in a direction at right angles to the general direction of the coast so that the wave exposure pattern is very complex. The zonation can be, and often is, completely altered by the degree of wave exposure to which the coast is subjected and with this complex wave exposure pattern it is difficult to decide on a zonation which is characteristic of normal wave exposure, especially since there are reefs just offshore which cannot be inspected.

The most surprising feature is the formation of a *Littorina* zone which is clearly defined and distinct from the barnacle belt. This condition is widespread at Playa Blanca but at Primeros Rocas the *Littorina* belt is incorporated in the barnacle belt in what is to be considered the normal condition for the Chilean coast.

The barnacle belt is divided into two parts, an upper being composed of *Chthamalus cirratus* and a lower of *Chthamalus cirratus* and *Balanus laevis laevis*. At Primeros Rocas the barnacle belt is wide but the barnacles are not numerous and there are a large number of *Siphonaria lessoni* living in the belt, as well as a considerable quantity of *Ulva lactuca* L. There are two species of Patelloids which are sufficiently numerous to give character to the belt and could almost be described as a *Patelloid* belt. The limpets are *Acmaea viridula, Collisella araucana* (D'Orb.). The whole area of Primeros Rocas is very exposed to heavy wave action and this factor gives a considerable amount of spray which is responsible for the development of Patelloids to almost a belt-forming species. *Chiton cumingsi* and *Chiton latus* are found in clefts in the barnacle belt. The larger clefts in the barnacle belt frequently sheltered individuals of the species *Heliaster helianthus* (Lam.) (Asteroidea).

It is with some hesitation that I have granted *Colpomenia* the status of a belt-forming organism. The alga is very numerous, forming typical bladder-like clusters over a large area of the shore. Much of the substratum utilised by *Colpomenia* is formed by mussel beds and these animals are the most numerous on the shore. It is *Colpomenia* that lends character to the shore and for that reason this species is raised to the status of a belt-forming organism. However, it is more than likely that *Colpomenia* is subject to seasonal variation and at times of the year other than summer the species may be almost absent. At Primeros Rocas there is very little *Colpomenia* present, the dominant organism on that part of the shore being *Mytilus* sp. with *Brachidontes purpuratus* in the upper part of the mussel belt. The mussels have *Balanus flosculus* living on their shells as well as a small *Acmaea* sp.

The *Corallina* belt consists not only of *Corallina* but also of four other species of algae, namely *Halopteris hordacea, plocamium pasificum* Kylin, *GlossopPhora kunthii* and *Rhodymenia* (=Dendrymenia) *corallina* (Berg) Taylor.

The lower part of the shore is dominated by algae, namely the small *Corallina chilensis* followed at lower levels by *Lessonia nigrescens* with *Lithothamnia* forming a continuous covering to the rocks. There are three obvious species of *Lithothamnia,* a purple-red coloured species, a deep red and a pink, the latter being the most common. The species of these *Lithothamnia* occur mixed altogether at different levels though the purple-red species prefers situations with some degree of sun shelter. The *Lithothamnia* belt is also occupied by *Lessonia nigrescens* and *Acanthopleura echinata, Enoplochiton niger, Concholepas concholepas, Fissurella costata, F. limbata, Thais chocolata* (in clefts), *Turbo niger* and *Tegula atra*. The roots of *Lessonia* holdfasts offer a sheltered habitat to the crabs *Pachycheles grossimanus* and *Petrolisthes patagonicus* (Cunningham). One specimen of the "patelliform" Isopod, *Ahphoroidea typa* H. M. Edw., was collected on the stipe of *Lessonia* and the roots were the subject of attacks by the Acmaeid *Scurria scurra*. One small octopus, *Polypus fontanieanus* D'Orb., was captured amongst the *Lessonia* holdfasts.

(*d*) *Arica*

This port was visited between 26th and 28th February, 1955.

The area examined was on the rocks to the south of the Balneario to the south of Arica.

The zonation: On the rocks beyond the shipyard at the southern end of the Balneario:—

Chthamalus cirratus.
Chthamalus cirratus + *Littorina peruviana.*
Chthamalus cirratus + *Balanus flosculus.*
Chthamalus cirratus + *Balanus flosculus* + *B. laevis laevis.*
Barnacles + *Brachidontes purpuratus.*
Lessonia nigrescens.
Lithothamnia.

The top of the *Chthamalus* belt varies in different places. There are three such varieties. The most common is that given above where the barnacles are the only organisms living high on the shore. In sun-sheltered situations which have some spray there is the expected reversal of *Littorina* and *Chthamalus* with the barnacles occurring lower than the littorinids. In some places the *Chthamalus* and *Littorina* belts occur together as a mixed belt at the top of the shore. The places where this happens presumably are intermediate in sun and wave exposure to the exposures experienced by the areas showing the first two types of zonation. It is apparent that the mixed zones at the top of the shore occur in places where there may or may not be sun exposure.

The barnacle belt changes in constitution further down the shore. *Chthamalus cirratus* is still found but it is mixed with *Balanus flosculus* and a few *Balanus laevis laevis,* the latter species being specially numerous on mussel shells only in very shaded places. In the lowest parts of the barnacle belt there are more *B. l. laevis* with proportionately fewer *C. cirratus* and a large number of *B. flosculus*. In this region it is difficult to decide the dominant species of barnacle, since dominance changes from place to place and it can only be referred to as a barnacle band. *B. flosculus* is very common on *Brachidontes* and *Mytilus* and *B. l. laevis* is also found on these species as well as on Concholepas. It is interesting to note that Darwin (1854) recorded *B. flosculus* as occurring together with *Chthamalus scabrosus* Darwin, especially upon *B. psittacus*. I did not collect any *C. scabrosus* in Chile in 1955.

Siphonaria lessoni and *Acmaea viridula* are both very numerous in the barnacle belt together with *Chiton cumingsi, C. latus* and *Fissurella concinna* Philippi.

The lower part of the barnacle belt consists of *B. flosculus, B. l. laevis,* and *Chthamalus cirratus,* together with *Brachidontes purpuratus*. The mussel appears at first fairly high up the belt as a cleft dwelling species but at the lower tidal levels it is present in large numbers forming a dense covering to the rocks. The mussels themselves serve as a substratum for the barnacles, *Ulva lactuca, Enteromorpha* sp., *Acmaea* sp., *Siphonaria lessoni, Chiton cumingsi* and *C. latus*.

The top of the Infralittoral fringe, characterised by *Lessonia nigrescens,* occurs very abruptly at the lower end of the *Brachidontes* belt. The red alga

Gigartina lessonii (Berg) J. Ag. is found on the mussels in the lower parts of the mussel beds and this alga also extends into the Infralittoral fringe.

The *Lessonia* belt is very well developed and also found in this belt, being very common, is *Gigartina lessonii*. During the period of examination of the rocks it was not possible to examine this belt satisfactorily on account of a heavy ground swell. The crabs *Petrolisthes angulosus* (Guérin), *Pachycheles grossimanus* (Guérin), and *Gaudichaudia gaudichaudii* (H.M. Edw.) live in the "roots" of the holdfast of *Lessonia*. Also found in the same habitat are *Concholepas concholepas, Acanthopleura echinata, Enoplochiton niger, Fissurella costata, Tegula atra* and *Thais chocolata*, together with an Asteroid *Stichaster striatus* Muller and Troschel.

In the shale below stones in gulleys and ponds there is a numerous annelidan fauna consisting of ten species. These are *Lepidasthenia virens* (Blanchard), *Halosydna fuscomarmorata* (Grube) (Polynoidae), *Eulalia personata* (Gruvier) (Phyllodocidae), *Nereis grubei* Kinberg (Nereidae), *Lumbrinereis* sp. (Lumbrineridae), *Pherusa* sp. (Flabelligeridae), *Dasybranchus* sp., and another capitellid (Capitellidae), *Phragmatopoma moerchi* Kinberg (Sabellaridae) and *Thelepus* sp. (Terebellidae).

The *Lessonia* belt is replaced by a *Lithothamnia* dominated region. Most of this latter belt is submerged at low tide but the prevailing heavy swell is such that a considerable part of the top of the *Lithothamnia* is exposed intermittently.

Discussion

Throughout this paper I have not raised *Brachidontes* to the status of a belt-forming species. I am reluctant to do this since it has been found that mussels are a rather unstable indicator, being liable to fluctuations in numbers due to storms and long term variations in population numbers. For this reason, I prefer to think of mussels, of either of the two genera *Brachidontes* or *Mytilus*, as forming part of the lower barnacle belt. This is in contradiction to my earlier papers wherein I refer to a belt dominated by *Mytilus* or other mussels.

The large chitons *Enoplochiton niger* and *Acanthopleura echinata* are found at all of the localities visited in the Infralittoral fringe on the rock unoccupied by the holdfasts of *Lessonia*. However, while these chitons are large and obvious, there are certain other species which are of small size but of no less ecological significance. The most numerous chiton is *Chiton cumingsi*, found at high tidal levels and in clefts and ponds at all four localities. *Chaetopleura peruviana* (Lam.) is an equally widespread species being found not only in clefts but also under stones. Leloup (1956) records it from clefts, under stones, from low to high tide level, from rocks embedded in sand, from rock cavities and in association with *Brachidontes purpuratus*. *Chiton granosus* Frembly was recorded from Coquimbo and Iquique by the Lund University Expedition (Leloup, 1956) and I found it high on the shore in clefts at both these places as well as at Antofagasta but not at Arica. Brand (1945) apparently did not find the species in Arica. *Chiton latus* Sowerby was found at Coquimbo living at the level of *Endarachne* and at Iquique living on stones at the level of the top of the *Lessonia* belt. I did not find this species at Arica, though Brand (1945) recorded it from there, but without any habitat notes.

It has been found that in other parts of the world the zonation pattern is controlled in the widest sense by the geographic range of the belt-forming species. In the more restricted local areas one of the prime causes of changes of zonation is the amount of wave action to which any particular part of the coast is exposed. On a much incised coast line care has to be taken that the area examined is typical of the coast as a whole and is not just a small local patch exposed to a certain amount of wave action. On the Chilean coast, north of Chiloë Island, this factor plays a relatively important part. Most of the coast between Valparaiso and Arica is exposed so that the zonal pattern is easy to identify and the pattern in any restricted area was found to be typical of a considerable length of coastline.

One of the most surprising features of the central and northern Chilean coasts is the uniformity of the zonation. Table 4 summarises the zonation encountered at the five places where an examination of the shore was carried out.

The above table shows firstly that there is very little change in the belt-forming species on the shores of Chile throughout 15 degrees of latitude. There may be some slight changes in the actual species composition but, with the one important exception at Antofagasta, the zonation falls into the one type, namely, barnacle, barnacle and littorinid, barnacle, algae and mussels, algae. The exception at Antofagasta is most interesting. It has been shown in the section above that there is some evidence for assuming that the sea temperatures at Antofagasta are higher than at other adjoining places both to the north and to the south. If we are to accept that the species inhabiting the Infralittoral fringe reflect the nature of the waters washing them, then the presence of *Pyura* as an intertidal indicator at Antofagasta can be interpreted as a biological indication of warm water conditions. *Pyura* in other parts of the world. e.g., Australia, forms extensive and ecologically very similar belts in warm temperate seas. *Pyura chilensis* is by no means confined to the Antofagasta area, but is found on the Infralittoral fringe amongst the holdfasts of algae from Peru to 42° S. approximately (Van Name, 1954). However, throughout the rest of the range of the species there are no large beds formed in the same fashion as at Antofagasta.

It could well be that at Antofagasta there exists some set of local conditions which does not favour the growth of the Infralittoral fringe algae. It may even be that some catastrophe befell these algae and they were replaced in the shore by the ascidians which became so numerous that the algae are unable to compete in their accustomed habitat. If the latter had taken place, one might expect to encounter scattered patches of *Pyura* throughout the whole Chilean coast, in places where gales had temporarily removed the algae. However, this is not the case.

The absence of the littorinid belt from the Supralittoral fringe is a feature of the Chilean coast which has already been noted earlier (Guiler, 1959). There may be some competition between the littorinids and the barnacles and field evidence suggests that there exists a very delicate balance between the rate of drying and the amount of wetting experienced which may confer some advantage upon the barnacles. However, it is by no means general to find the Supralittoral fringe devoid of littorines, e.g., at Iquique there exists a well developed *Littorina* belt and these conditions are duplicated at several places on the coast at Montemar where local conditions give rise to restricted areas showed that there was not heavy spray beating upon the rocks. In areas where the spray was heavy and more or less continuous it was noted that the littorines formed a sub-belt within the barnacle belt.

The most common of the intertidal belt-forming barnacles is *Chthamalus cirratus*, this species being recorded as that which forms the upper Midlittoral belt at all places visited. It is particularly interesting to note that Darwin (1854) recorded *Ch. cirratus* as frequently occurring with *Ch. scabrosus* Darwin. My collections failed to yield any of the latter species at any of the stations visited, nor were any collected as dead material washed ashore. The absence of *Ch. scabrosus* can only be a matter of speculation.

Ch. cirratus is a widespread species in South America, ranging from Peru to the Falkland Islands. Over all this range it is an important belt-forming species.

The lower parts of the *Ch. cirratus* belt become mixed with other species of barnacle, namely *Balanus l. laevis* and *B. flosculus*. Darwin records both the species from the lower parts of the shore but Pilsbury (1910) only records *B. l. nitidus* from Peru. However, there is little doubt that *B. flosculus* occurs in Peru, Darwin recording its range from Peru to Tierra del Fuego. *B. flosculus* is a highly characteristic species, having a purplish shell.

While discussing barnacles it is desirable to mention the large *B. psittacus*. This is the largest of the operculate species, often reaching more than nine inches in length. Darwin did not record this species as being of intertidal occurrence but I found it to be numerous in the Infralittoral fringe at all parts visited. However, the only place where *B. psittacus* formed a belt was at Coquimbo, but it is certainly of considerable ecological importance on the other part of the coast on the rock living among the holdfasts of the large algae. The presence of a belt formed by this species in the lower Midlittoral was attributed to special conditions which resulted in an elimination of the algae. Perhaps Darwin did not find any of this species intertidally because it happens to be edible and thus liable to predation. He found it living on the mollusc *Concholepas* and he gave its range as from Arica to Chiloë Island. Pilsbury (1910) extended the range of *B. psittacus* to Callao and the Chincha Islands in Peru.

B. psittacus is often associated with other species of barnacles which make use of its shell as a substratum. These species are *B. laevis, B. flosculus, B. trigonus* Darwin and *Verruca laevigata* Sowerby. The latter two species were not found by me but were recorded by Darwin.

The lower parts of the Midlittoral are occupied by various species which form belts at different parts of the coast. Mussels reach considerable importance at various places and are usually utilized as a substratum by barnacles, e.g., *B. flosculus* and *B. laevis*. There is little uniformity in the belts found on the coast and the species forming them will be discussed later.

TABLE 4.

Zonation at Five Places on the Central and Northern Chilean Coast

	Montemar Lat. 33° 12′ S.	Coquimbo Lat. 29° 55′ S.	Antofagasta Lat. 23° 40 ′ S.	Iquique Lat. 20° 15′ S.	Arica Lat. 18° 20′ S.
Supralittoral fringe	Vacant	Vacant	Vacant	*Littorina peruviana*	Vacant
Midlittoral	*Chthamalus cirratus*	*Ch. cirratus*	*Ch. cirratus*	*Ch. cirratus*	*Ch. cirratus*
	C. cirratus + *Littorina peruviana*	....	....	....	....
		Ch. cirratus + *Endarachne binghamiae*	*Ch.* + *Enteromorpha* sp.	*Ch. cirratus* + *Balanus l. laevis*	*Ch. cirratus* + *Balanus flosculus*
		Ch. cirratus + *Balanus flosculus*	*Ch. Colpomenia*	*Colpomenia* + *Brachidontes purpuratus*	*Ch. cirratus* + *B. flosculus* + *B. l. laevis*
				Colpomenria + *Mytilus chorus*	*Barnacles* + *Brachidontes purpuratus*
			Pyura chilensis + *Corallina chilensis*	*Corallina chilensis* + *Tegula atra*	
		B. psittacus + *Acanthopleura echinata*	*Pyura chilensis*		
Infralittoral fringe	*Lessonia nigrescens* Bory	*L. nigrescens*	*Pyura chilensis* (Molina)	*L. nigrescens* with *Lithothamnion* spp.	*L. nigrescens*

The Infralittoral fringe is generally dominated by algae, with the important exception of the *Pyura* at Antofagasta. *Lessonia nigrescens* is the dominant alga of this belt. In northern Chile this species is the only large alga of the fringe but in central Chile, at Valparaiso, the large southern kelp *Durvillea antarctica* appears in small numbers, gradually increasing to replace *Lessonia* in southern Chile. These species are extremely easy to distinguish, *Lessonia* being short—about four feet in length, dark-chocolate in colour, with a many-branched holdfast, so typical of the Laminariales, while *Durvillea* is long, six feet or more in length, olive-brown or even yellow in colour, with a single sucker forming the holdfast.

(5) NOTES ON SOME INTERTIDAL SPECIES

Only those species which are common and of considerable ecological importance are described here.

(a) *The Littorinids*

There are three species of *Littorina* which occur in Chile. These are *L. araucana* D'Orbigny, *L. umbilicata* Orb. and *L. peruviana* (Lam.). The most common species, *L. peruviana*, is to be distinguished by a series of angled white marks on the shell. A synonym of this species is *L. zebra*.

The range of both these species has been recorded by various authors. Dall (1910) records *araucana* as occurring from Nicaragua to Valdivia and *umbilicata* ranging from Ecuador to Chile. Neither Gigoux (1934), Brand (1945), nor Bahamonde (1950) record the latter species from the north of Chile.

It is interesting to note that both *L. araucana* and *L. peruviana* are tropical in their ranges and in Chile, especially in the south, they are approaching the end of their geographical range. This may have some part to play in the absence of a well-developed littorinid belt over much of the Supralittoral fringe. At Iquique Playa Blanca there is a *Littorina* belt, formed by *L. peruviana*, but at Arica, to the north, and at all other places to the south of Iquique the *Littorina* belt is a strip contained within the barnacle belt. It has been noted in the case of some other species that animals approaching the end of their geographical range seek less rigorous environment. Unfortunately, there is no information on the shores of Peru, Ecuador or Colombia to enable conclusions to be draw regarding the habitat of the species on the shores of these countries, but it should be remembered that it is possible that their vertical range in Chile is not the characteristic habit of this species.

(b) *The Chitons*

The most obvious of the Chilean chitons are *Enoplochiton niger* (Barnes) and *Acanthopleura echinata* (Barnes), both species being widespread in distribution on the coast. *A. echinata* is easily distinguished by the presence of spines on the girdle, large size, and complex sculpturing. Although of large size, this species is not the most common on shore but is one of the most obvious. It is found in the lower Midlittoral and in the Infralittoral fringe, living on rocks or in clefts. Leloup (1956) records it from coarse sand. The individuals can tolerate the heaviest wave action and prefer the presence of some surf, being absent from sheltered places. *Acanthopleura* is found from the Galapagos Islands to San Vincente (37° S.). Plate (1898) records a specimen 20 cm. long x 10 cm. wide.

Enoplochiton niger can be differentiated from *Acanthochiton* by the presence of scales on the girdle. It occupies much the same type of habitat on exposed coasts as *Acanthochiton echinata* but it is not as widespread a species, being absent or scarce on parts of the coast not receiving the heaviest of wave action. This species ranges from Peru to Valparaiso and I collected specimens from Arica, Iquique, Antofagasta, Coquimbo and Montemar.

The smaller chitons are very numerous on the Chilean coast and the most common of these is *Chiton cumingsi* Frembly. Leloup (1956) records this species from Chiloë Island to Iquique but Dall (1910) found it in Peru and I collected specimens at Arica, as did Brand (1945). Dall noted that the chiton occurs in rock pools and on rocks so that it is apparent that this species occupies the same habitat in Peru as in Chile. Bartsch and Rehder (1939) give the range of the species as Callao to Chiloë.

Chiton cumingsi lives attached to rocks in the Midlittoral both on open faces and in clefts. It also frequents ponds and clefts in the bottom of ponds as well as occupying a semi-cryptic to cryptic position below rocks and boulders.

In the upper Midlittoral *C. cumingsi* is partially replaced by *C. granosus* Frembly. This species ranges from Callao to Magellan (Dall, 1910). Leloup records this chiton from the Infralittoral to the highest part of the tidal region, living under stones and in cracks in the rocks.

The third common widespread small chiton of the Chilean coast is *C. latus* Sow. Dall (1910) only recorded this species from a restricted part of the Chilean coast, namely from Valparaiso to Coquimbo, but Leloup (1956) gives the range of this chiton as from Callao to Magellan. It is found at all tidal levels. I collected it from all places visited and both Brand (1945) and Bahamonde (1950) record it from northern Chile.

Tonicia elegans (Frembly), which I collected only from below rocks embedded in sandy shale at Montemar, is a widespread species. Gigoux (1934) recorded it from the Atacama region, and Dall (1910) stated its range to be from Callao to Chiloë. Leloup followed Dall in his statement of the range of the species. Leloup recognised four forms of this chiton, *f. chilensis* Frembly from Coquimbo, Valparaiso, Talcahuano, Puerto Montt, San Vicente and Lota, *f. chiloensis* from Chiloë and S. Chile, *f. gravi* from Tocopilla, Ancud and Canal Chacao and *f. lineolata* from Valparaiso, Talcahuano, Coquimbo and Iquique.

Chaetopleura peruviana (Lam.) is a widespread species occurring along the whole of the Chilean coast. Leloup (1956) records it as being found from Iquique to the Magellan Straits. Gigoux (1934) records the species from the Atacama and Bahamonde (1950) found this chiton on the Tarapaca coast, at Cuya, Los Gringos and Caleta Vitor. I collected the species at Montemar in clefts at

about mean sea level and in a similar habitat at Coquimbo. I did not find this species at Antofagasta, Iquique or Arica.

Leloup cites three chitons having a Magellanic distribution, eight from Chile and Magellan, nine from Chile and Peru, seven from Peru to Magellan, and two from Chile to Mexico. The centre of distribution of the chitons is thus more concentrated in central Chile than in the north or south, although some of the species are of very widespread distribution, reaching the Antarctic, e.g., *Tonicia elegans*, and the Argentine, e.g., *Chiton latus*.

(c) *The Fissurellids*

The family Fissurellidae reaches a considerable degree of development in Chile, Riveros (1950) describing no fewer than 37 species. One of the most evident of the fissurellids is the large *F. crassa* Lam. This species reaches 85 mm. in length and has a somewhat depressed shell. Its geographic range is from Callao to Corral. The larger *F. nigra* Lesson is less common than *crassa* but more widespread in range, reaching from Callao to Magellan Straits.

Several other fissurellids are found intertidally in Chile, notably *F. exquisita* Reeve, *F. concinna* Philippi and *F. limbata* Sowerby. However, all of these species are found in clefts or other semi-cryptic or cryptic places.

The fissurellids are most common and show the largest number of species in southern Chile. Riveros (1950) records 13 species which are exclusively Magellanic in distribution. These species have a very wide range from Magellan to Peru, four species range from Valparaiso to the north, but only two species range from Valparaiso to Magellan. Two species range from Magellan to Chiloë Island and two range from Chiloë to Valparaiso, while four species are of widespread occurrence from Valparaiso to Peru. Of the remaining seven species, five are local in occurrence and some doubt exists as to whether two species occur in Chile. The distribution of the species superficially shows that the Valparaiso area is of geographical importance since no fewer than 10 species appear to end their ranges at that port. However, there has always been much greater emphasis of collecting in the Valparaiso area than in other parts of Chile and undue emphasis must not be placed upon these records. It is apparent that there is a general diminishing of the number of Fissurellids in northern Chile, from the 20 species in the Magellan region to seven at Arica.

(d) *Other Species*

One prominent member of the Infralittoral fringe fauna is *Concholepas concholepas* Bruguiere. This large mollusc is found from Peru to S. Chile. As this species approaches the northern end of its range it is smaller than in southern Chile and at one time the Peruvian specimens were described as a different species *C. peruviana* Lam. *Concholepas* appears to fill a *Haliotis*-like niche, being an alga grazer living at or below the Infralittoral fringe.

The limpet *Scurria scurra* (Lesson), although not conspicuous, is of very considerable ecological importance since it lives in amongst the roots and stalks of *Lessonia*. It causes damage to the plants and eventually may be indirectly responsible for the removal of the plant from the substratum.

(6) GENERAL

The north Chilean coast, throughout its great length shows a considerable change in its climate. The northern parts of the coast are characterised by rare rainfall, heat, strong insolation and dry conditions generally, whereas the central coasts have a Mediterranean climate with dry warm summers and wet mild winters. From the north to central Chile the analysis of the physical environment shows that some amelioration of the full possible effects of insolation and dehydration on the desert coast are found in the almost continual spray and frequent mists but this has the disadvantage that hypersalinity becomes an almost permanent feature of the intertidal region. The central Chilean coast, on the other hand, shows a very sharp difference between summer and winter conditions, with seasonal rains playing an important part in altering the exposure and salinity factors. Therefore it might be expected that the species inhabiting the central parts of the Chilean coast could be different from those found in the north, if not on account of the large geographic distance between them, but because of the different climates experienced in this distance. However, this is not the case. Not only are the species to be found on the shore the same but they occupy the same ecological levels on the shore and apparently have the same ecology at Arica as at Valparaiso.

There could be expected that a physiological difference exists between, say, an individual *Chiton latus* from Arica and one from Valparaiso. The northern individual must be physiologically adapted to withstand different climatic conditions from one from the south. It would be very interesting to carry out transplant experiments upon some of the intertidal species.

All northern and central coasts show the same type of zonation, namely barnacle, littorine, barnacle, algal with mussels and, finally, algal zones. Minor variations of this may occur, but the basic pattern is unchanged. The important exception to this is at Antofagasta. At this port the lower part of the shore is occupied by *Pyura chilensis* and not by large Phaeophyceae. In the discussion of the physical environment at the port I concluded that local meteorological factors produce somewhat warmer conditions at Antofagasta than at places on either side of this region. This, apparently, has no effect upon the intertidal fauna with the exception of *Pyura*, which becomes dominant. *Pyura* is widespread along all of the coast of Chile, but it is only at Antofagasta that it forms a belt and it is this feature which gives a clue as to the factor controlling the zonation on the Chilean coast.

Obviously, since the zonation is the same both in north and central Chile, air temperature, insolation and other climate factors can be ruled out as controlling influences. The sea temperature must be the factor which controls the distribution of these organisms. Figure 4, showing the sea temperature gradient graphically, illustrates that there is only 3° C. difference in the mean winter temperatures. Such a small gradient as this spread over such a great distance could not be expected to give major change in biogeographical regions.

The warmer maximum temperatures prevailing at Antofagasta are sufficiently greater to encourage the development of *Pyura* which is a species that favours warmer seas than those preferred by the Phaeophyceae.

The direction of the currents probably plays no small part in the apparent inability of tropical elements to penetrate into Chilean waters. Any larval recruitment to shore faunas on the Chilean coast must come from the south, i.e., from cold waters so that warm water species have little chance of spreading south.

The tropical element is entirely lacking on the northern Chilean coast. Although Arica lies well within the tropics there are no coral reefs to be found and mangroves are not a significantly important member of the flora to the south of Tumbes (Lat. 3° 30′ S.) in northern Peru (Peterson, 1949).

It is recognised that there are two main elements in the marine fauna of Chile, namely the cold temperate (Magellanic) and the warm temperature or Peruvian. It is convenient to start with the review of knowledge as interpreted by Ekman (1953) who thought it probable that there are two elements in the Chilean fauna and considered that the northern limit of the cold water province was at the northern end of Chiloë Island. He went on to note that nowhere else in the world is the limit of the tropic-subtropic so near to the Equator, being at Punta Aguja (6° S.).

Madsen (1956), in describing the distribution of the echinoderms of Chile, states that there are only three exclusively warm temperature species in the Chilean echinoderm fauna. There is also a transitional element occurring both to the north and south of Chiloë Island with a cold temperate element which is restricted largely, though not entirely to the south of Chiloë Island.

Haig (1955) and Holthuis (1952) record that numbers of species of Anomurous and Macrurous Decapod Crustacea reach the ends of their geographic ranges in the vicinity of Chiloë Island. In view of these conclusions it seems that the area of change from the Peruvian to the Magellanic Regions is fairly uniform and well defined.

However, there appears to be a considerable region of mixed faunas lying to the north of Chiloë Island. The echinoderms, for example, have a number of species which reach as far as Iquique but also extend well into the Magellanic province.

If we consider the zonal forces as indicative of the biogeographic provinces of Chile, we see that southern Chile with mussels, the large brown fucoid *Durvillea antarctica*, and a barnacle-littorine zonation on the upper part of the shore is characteristic of the generally accepted southern cold temperate type of zonation.

The southern warm temperature region is characterised by the presence of littorines, barnacles, *Lessonia* sp., *Phyllospora* sp. (large Phaeophyceae other than fucoids) with ascidians becoming important, e.g., in the Sydney area (Dakin, Bennett and Pope, 1948). This type of zonation is found over nearly all of the central Chilean coast where *Lessonia nigrescens* is the dominant alga of the Infralittoral fringe, with *Pyura chilensis* of some importance and even in some localities becoming of major zonal significance, e.g., at Antofagasta. Van Name (1954) recorded *Pyura chilensis* as not being a Magellanic species, but one which is intermediate between the warm waters of north Peru and the Magellanic region though reaches latitude 43° S.

There are certain other features shown by the non-zone forming species which lend support to evidence given by the belt-forming species. The very restricted ecological importance of the large limpets in northern seas is a warm temperate feature, since limpets apparently are smaller in size and less numerous in warm seas.

The work of Madsen (1956), Haig (1955), and Holthuis (1952) shows that, although there is a biographical boundary somewhere in the region of Chiloë Island, there is a very great deal of penetration of the Magellanic forms into the Peruvian Region. This is particularly true of the Crustacea and it is further supported by the work of Riveros (1950) on the Fissurellids, this latter author finding 15 Magellanic species out of a total of 37, and five species having a range extending from the Magellan Straits to beyond Chiloë Island and it would appear as if this group, while primarily Magellanic in character, extends its range well into the Peruvian Region. The distribution of fissurellids is shown in Table 4.

The region of Chile to the north of Chiloë Island can be considered as an area having the ecological characteristics of a warm temperate region but with a considerable penetration of cold weather elements. This penetration is assisted by the cold northerly flowing Peru Coastal Current and the presence of this current must be considered as the main element in maintaining the warm temperate fauna as far north as central Peru.

TABLE 4.

Species Distribution of the Fissurellids of Chile based on Riveros (1950)

No. of Species	Range	Province
13	Magellan Area	Magellanic
2	Easter Island	?
2	Magellan-Valparaiso	Magellanic and Peruvian
3	Magellan-Peru	Magellanic and Peruvian
2	Chiloë-Valparaiso	Peruvian
4	Valparaiso-Peru	Peruvian
2	Magellan-Chiloë	Magellanic
4	Valparaiso-N. Chile	Peruvian
3	Valparaiso only	Peruvian
2	Doubtful	
37		

(7) PHYSICAL FACTORS ON THE EAST AND WEST PACIFIC COASTS

Throughout this section the reference to the western Pacific coasts will be understood to refer to the coast of Chile to the north of the 35° of latitude, unless it is specifically stated otherwise. In this section a full review of the factors is not given, this having been done earlier, but a brief summary of these factors is given below.

(*a*) *Currents and Upwellings*

The currents on the Australian coast and the Chilean coast are opposite in their direction of flow. On the western shore the current, the Peruvian Current, flows north and it has been shown to be cold in nature and is frequently kept cool by reinforcements of cold water from upwellings. The latter are the result of the effect of trade winds blowing on the Andean chain and so being diverted to a direction parallel to the coast. There is a counter current, warmer in temperature than the offshore Peruvian Current, which runs south down the coast. This can be compared with the Australian current system where a warm current pursues a southerly course down the Australian coast.

The sea temperatures differ greatly on the eastern and western sides of the Pacific. The temperature of the sea is a result of the current pattern and, whereas the Australian sea thermocline shows an inverse relation to latitude, the Chilean and Peruvian coasts may even show a decrease in temperature towards the tropics (Fig. 22).

Fig. 22. Comparison of Australian and Chilean sea temperatures.

The Australian coast at comparable latitudes is over 5° C. warmer than the Chilean and southern Peruvian coast. The difference becomes more pronounced in the tropics where there is almost 10° C. between the temperatures at latitude 17° S. This divergence becomes marked to the north of 17° S., but there is no very marked divergence in the temperatures to the south of 33° S.

(*b*) *Winds*

In both cases the coasts are subject to the trade winds and also the southern part of each coast, i.e., Tasmania and southern Chile, are battered by the westerlies of the " Roaring Forties ". The trade winds of Australian seas are not diverted by any mountain chain comparable to the Cordillera of Chile so that the pursue their normal southeasterly course, whereas those of Chile are diverted from their normal course to southerlies. Both coasts are subject to sea breezes in summer which may reach considerable strengths, but they are purely local coastal phenomena and do not whip up strong heavy seas, but they can create a short sharp sea which has a considerable effect in producing spray. However, the two coastlines have similar winds, although they on the shore are each the result of different conditions.

There are small variations in the salinities encountered on both the Australian and Chilean coasts but it seems unlikely that these are sufficiently great to cause major changes in the flora and fauna on any part of the coast.

The air temperature gradients of the two coasts show that the Australian air temperatures are warmer than those at comparable latitudes on the Chilean coast. The temperature difference becomes more marked in the tropical rgions of each country, being in the order of 10° C. at 20° S., whereas at 40° S. the difference between the temperatures is about 7° C.

The isanomalous lines on the Chilean and Peruvian coasts show a greater negative departure than those on the Australian coast, but the greatest difference lies, not in the negative departure, but in the fact that most of the Australian coastline shows a positive departure with the exception of the Tasmanian-Victorian region in summer. That is to say, the annual mean sea temperature is greater than the annual mean air temperature in Australia, whereas the opposite holds good on the west coast of South America.

The fogs and mists, so prevalent on the Chilean coast, especially the northern parts of it, are lacking on Australian shores which are remarkably free of fog. The origin and effect of the Chilean mists have already been commented upon and no further observations are necessary at this stage, beyond noting that they may bring some moisture to the coast.

The rainfall on the two coasts is notably different. The rainfall in Chile is remarkably Mediterranean in type with maximum falls occurring in the winter and virtually no rain in the summer. North of 30° S. the rainfall becomes very irregular and on the desert coast of northern Chile and southern Peru precipitation may not take place for many years. The Australian rainfall pattern is very different, in general there being more rain in the tropical parts of the coast than in the cool or warm temperate regions.

The mean annual relative humidity figures suggest that the Australian coast is dryer than that of Chile, even including the desert area of northern Chile. The Australian State capitals, all coastal cities, have a mean annual humidity around 68%, whereas in Chile the relative humidity varies from 74% at Antofagasta to 83% at Valdivia (see Fig. 9). The greater moisture in southern Chile is derived from the very heavy annual precipitation and the moist damp climate while that in the north is brought about by the mists and fogs of the Peru Current.

The wave action experienced on the eastern and western sides of the Pacific Ocean is intense. The battering received by the shores of New South Wales, western Tasmania and Chile is among the most intense in the world, while the remainder of

the Australian coast receives somewhat less intense wave action.

The Chilean and Peruvian coasts are unique in the world in one feature, namely the Nino effect, the warm tropical water which periodically sweeps down the coast bringing disaster to marine organisms. No other coastline suffers such a phenomenon. The Australian coast has occasional "red sea" blooms which have been noted from time to time. These are very local in effect and also occur on the Chilean coast.

The differences between the two coasts are shown on Table 5. On the west of the Pacific there is a coast bathed by cold water up to 7° C. cooler than the air, with winter precipitation between the latitudes of 30° S. and 40° S. and very little, if any, precipitation at intervals of many years to the north of these latitudes but with some mists or fogs and high relative humidity. The whole coast is subject to intense wave action. The northern portion of the shore is liable to periodic mot tropical fauna and flora. All the physical factor sexcept water invasions which have serious effects on the the last, combine to modify the effect of the warm climate.

On the other hand, the Australian coast is bathed by warm water which gradually cools in the higher latitudes, the precipitation is high and the relative humidity low. The Australian coast can be considered as more normal in its climatic pattern that than of Chile, which is only paralleled by the desert coast of South-West Africa.

(8) THE CHILEAN INTERTIDAL ZONE IN RELATION TO THAT OF AUSTRALIA AND SOUTH AFRICA

The physical conditions of the South African coast are somewhat similar to those prevailing on the South American coasts, namely a warm current flowing southwards along the east coast of the continent with a cold northerly current on the west coast. Further, the South-West African coasts resemble those of Chile in that the similar special oceanographic and climatic conditions produce a cold sea backed by a desert coast with few centres of civilisation. However, the west coast of South Africa is colder than that of northern Chile, the temperature being between 12° C. and 16° C. (Isaac, 1937), whereas that of northern Chile is 16-19° C.

The features of the higher parts of rocky coasts show a uniformity throughout the world, and are dominated by two forms, namely littorines and barnacles. In order to seek significant points of resemblance or contrast between coasts, we must turn to the lower parts of the shore, and for this reason only the Infralittoral fringe and a few of the organisms of the lower Midlittoral are considered here. Before doing this, it is necessary to note the rather special Chilean habitat of the littorines which mainly form a belt in the top of the barnacle band.

The Infralittoral Fringe

It is convenient to start with the cold temperate regions of each continent. The cold temperate region of South Africa is represented by the west coast fauna and the algae of the Infralittoral fringe are *Laminaria pallida, Ecklonia buccinalis* and *Macrocystis pyrifera* (Bright, 1938, Stephenson, Stephenson and Day, 1940). *Pyura stolonifera* and *Lithothamnia* are found amongst the holdfasts of the algae. This type of zonation is somewhat similar to that encountered in northern Tasmania, but there are several important points of difference. The dominant alga of the Infralittoral fringe in Tasmania is *Sarcophycus potatorum* which differs from *Laminaria pallida* not only in its systematic position but also in the form of the holdfast which in the former genus is a large sucker. Thus, *laminaria* offers a niche for small species which is not found in Tasmania. Both South-West Africa and Tasmania have Lithothamnion and *Corallina* forming important belts in the lower shore, the latter occurring above the large algae in both countries. The Chilean algae of the Infralittoral fringe are similar to those found in Tasmania, namely the large *Durvillea antarctica* with *Lithothamnion* and *Pyura*. Although *Durvillea* is generically separated from *Sarcophycus*, the ecological resemblance is very close.

The genus *Ecklonia* is represented in both Australia and Africa but is of greater ecological importance in South-West Africa. *E. radiata* is found in Tasmania but it is confined to sheltered localities and is not numerous, which is in contrast to the situation in South-West Africa, where *E. buccinalis* is a dominant species over much of the coast. *Ecklonia* is absent from Chile.

TABLE 5

Comparison of the Physical Factors on the Australian and Chilean Coasts

	Chile	Australia
Sea current	Northerly, cold with cold upwelling	Southerly, warm
Winds	South to south-east	South
Sea temperature	No direct relation to latitude	Varies indirectly to latitude
Air temperature	Cool	Warm
Isanomalous departure	Negative up to 7° C.	Positive
Rainfall	Varying from very low and irregular to very high in south	Higher in tropics, regular, moderate
Relative humidity	High	Low
Fogs	Frequent	Rare
Wave action	Intense	Intense
Catastrophes	Frequent, widespread Ninos	Rare, local

Macrocystis, which in South-West Africa is found in more sheltered situations, is found in Tasmania offshore on exposed coasts. I have only found *Macrocystis* occurring intertidally in appreciable quantities at one place in Tasmania, whereas in Chile the species is found quite commonly in an intertidal situation. The sharp difference between the ecology of the species in Tasmania from elsewhere raises doubts as to the specific status of the Tasmanian representatives of the genus.

The Chilean coast in the warm temperate regions is dominated in the Infralittoral fringe by *Lessonia nigrescens*. There are some restricted areas in which *Pyura chilenses* replaces *Lessonia* as the dominant organism of the Infralittoral fringe, e.g., at Antofagasta. A similar state exists in South Africa where *P. stolonifera* replaces *Ecklonia*, e.g., at Port Elizabeth (Stephenson, Stephenson and Bright, 1938), and some parts of the same species of ascidian, e.g., at Sydney. In more northerly parts of South Africa the genus *Ecklonia* is not represented by the very large *E. buccinalis* but by the smaller *E. radiata*. This latter species is very common on the warm temperate Australian eastern coast, where it is the dominant alga of the Infralittoral fringe.

A feature of South African coasts is the presence of a belt containing 38 mixed species of algae in the Infralittoral fringe (see Table IX of Stephenson, 1939). An ecologically similar mixed algal strip is encountered on both Chilean and Australian warm and cold temperate coasts. The species composition of the belt is different in the three continents but the genera *Laurencia, Gelidium, Caulerpa, Iridaea, Dictyota, Centroceros* and *Plocamium* are all represented as well as Corallines of several genera. In many places, the Corallines are dominant in this region.

The Midlittoral

Mussels reach belt-forming importance in the cold temperate regions of all three continents, Chile and Tasmania sharing the same genera, namely *Brachidontes* and *Mytilus*. The former genus is absent from South Africa but *Mytilus* is represented there by three belt-forming species.

The limpets are of small importance in both Chile and Tasmania but are of great importance in South Africa where the genus *Patella* is represented by 11 species (Stephenson, 1936). The genus *Patella* is absent from Chile and Tasmania, being replaced by *Nacella* and *Cellana* respectively. On the other hand, the Siphonariid molluscs are of considerable importance in all three continental masses, the species of this genus being especially numerous on the upper part of the shore. The Fissurellid molluscs, of little ecological importance in Australia and South Africa, are of great significance in Chile, as also are the Turbinids.

It would be possible to contrast further belt-forming species on the coasts of the three continents but little is to be gained by so doing since sufficient has been shown above to illustrate that there exists an *ecological* similarity of the zonation on the coasts of the three geographical areas. However, the Australian coast differs sharply from that of the other two coastlines in that the tropic element, mainly the corals is very well developed. There are no corals in Chile and in South Africa there are only a few zoanthids although these and other tropic elements are represented in Natal.

There exists a closer relationship between the cold water regions on the three continents than is found on warm temperate or tropical shores. This is seen particularly in the algae of the Infralittoral fringe where the same species occurs, e.g., *Macrocystis pyrifera*. An apparent exception to this is *Ecklonia radiata* which does not occur in Chile but is found in South Africa and Eastern Australia, including Tasmania. However, a close relationship exists between the Tasmanian algae and those of Chile, some genera being shared, e.g., *Lessonia, Gelidium, Laurencia, Iridaea* and *Chaetomorpha*. Some species are found on both shores, namely *Adenocystis utricularis* (Bory) Skotsb., *Chaetomorpha aerea* Dilwyn and *Centroceras clavulatum* (C. Ag.) Mont. The same ecological habitat is occupied on each coast by each of the last three species. In these lists I have not included genera common to Chile and Tasmania but which also are elsewhere, e.g., *Corallina, Porphyra*, &c., these genera forming a ubiquitous element. The greatest similarity between Tasmania and Chile is the presence on the coast of the large southern kelps, *Sarcophycus potatorum* and *Durvillea antarctica* respectively. These kelps, although of different genera, are ecologically very similar, occupying the same niche in both countries. There is no anatomically similar South African kelp, though *Laminaria pallida* appears to occupy a similar habitat.

Apart from *Pyura* and the mussel belts mentioned above, there are few close relationships between the belts formed by animals on the Chilean and Australian coasts. Barnacles of the genus *Chthamalus* are found forming extensive belts in both countries. However, the surf barnacle *Catophragmus polymerus* is found in Tasmania but does not occur in Chile. Nor is it found in South Africa and it appears as if this species occupies a position in Australia which is utilised by limpets in the other countries. This supports the view of Ekman that the fauna of the west Pacific region is separable from that of the east. It is true that there are some species which are found in both continents, e.g., *Leptograpsus variegatus* (Fabr.), *Plagusia chabrus* (L.), *Cyclograpsus punctatus* M. Edw., *Halicarcinus planatus* (Fabr.), but the general ecological animal facies is different. At the family level there are a large number of similarities between the two continents but these are of rather doubtful value as a basis for biogeographical conclusions but the absence and relative importance of families is of some importance. The family Fissurellidae is extremely numerous in both species and numbers in Chile as are the Porcellanid crabs. Certain important Australian families, e.g., the Leucosiidae are poorly represented in Chile.

Stephenson (1948, fig. on p. 220) showed that the warm current of the eastern coast of South Africa favoured the spread of the warm water elements further down the coast than on the west where a cold northerly current limited the spread of the warm water element. The maximum penetration of these elements is almost to East London and to

Walvis Bay respectively. Stephenson stated that the fringe of the tropical fauna reaches Natal, say at latitude 30° S. The southern limit of this fauna on the western coast is about Cabo Frio (Lat. 18° S.). Thus the difference in latitude between the southernmost limits of the warm element is 12 degrees of latitude. The cold temperate region on the western coast of South Africa extends through approximately 22 degrees latitude.

The difference in latitude between the southern limits of the tropic regions in Australia and western South America is about 20 degrees, or some 1,400 miles, the tropic region in South America only occupying some six degrees. The warm temperate fauna of Australia extends through 12 degrees of latitude before it is replaced by the cold temperate region, whereas in South America it crosses some 35 degrees of latitude, most of the west coast of the latter continent being in this region. These figures serve to emphasize the profound effect that the strong Peruvian Current has upon the intertidal life.

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Plate 2.

The zonation at Iquique, 25th February, 1955. *Lessonia nigrescens* is the large alga, the rocks in the foreground are covered with *Lithothamnion*. The upper rocks in the middle distance are barnacle covered.

Plate 1

The *Pyura* belt at Antofagasta, 22nd February, 1955.

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THE GEOLOGY OF THE PONTVILLE-DROMEDARY AREA, TASMANIA

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(With 1 Plate, 2 Figures and 2 Maps)

ABSTRACT

More than 1,500 feet of flatly-dipping Permian mudstones, sandstones and limestones have been divided into nine units, and are overlain with probable disconformity by 1000 + feet of Triassic sandstone and shale, the former rock type being dominant. Jurassic (?) dolerite intrudes the Permian and Triassic sediments in the form of dykes, gently transgressive sheets and sills. The distribution of the various rock types, along with the strong Tertiary tensional faulting, has controlled the structure of the area and hence the development of the present-day topography. A flow of olivine basalt, about 200 feet thick, partly filled the valleys of the Jordan River and its tributaries, probably in late Tertiary times.

INTRODUCTION

The area mapped consists of two ten-kiloyard squares, 5074 and 5174, the Dromedary and Pontville squares respectively, which are part of the Brighton one mile (Army) map sheet. The area is situated between twelve and twenty miles north of Hobart on the main Hobart-Launceston Highway. Mapping was carried out in the field by walking the outcrop or contact and pinpointing it on aerial photographs. A base map was constructed by means of a slotted template laydown on a grid to the scale of four inches to the mile, using trigonometrical stations to provide the horizontal control. The topographical detail and the geology were then transferred directly from the aerial photographs by means of a rectiplanograph. All grid references within the text are given in the normal manner as used by the Army. Specimens referred to in this paper are in the collection of the Geology Department, the University of Tasmania, and the specimen numbers quoted are the catalogue numbers in that collection.

PREVIOUS LITERATURE

Johnston (1888) makes reference to the Dromedary Permian rocks but no detailed work was recorded by him. However, Nye (1922) mapped the area in a broad regional survey, and Lewis (1946) has also covered part of the Pontville square in a similar manner.

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PHYSIOGRAPHY

The major controlling factor of the physiography of the area has been the Tertiary faulting, and the distribution of the rock types has played a secondary, but still important, role.

The greater part of the area consists of rounded, but commonly steep-sided, hills rising up to 800 feet above the relatively broad open valleys. In the main the hills are of dolerite and the valleys are eroded in softer Triassic sediments.

The faults in general strike in a north-westerly direction and downthrow to the north-east, and it is within the resulting downthrown blocks that the main drainage takes place in a direction approximately parallel to the fault trend. The block on the downthrown side of the Dromedary Fault appears to have been tilted in towards the fault so that a distinct trough was formed in front of the fault scarp along which the River Jordan flows. Numerous south or south-west flowing consequent streams have developed on the slopes of the tilted block together with north-east flowing streams from the upthrown rock. The course of the Bagdad Rivulet may be similarly controlled.

The upthrown side of the north-west trending Dromedary Fault may be considered as a physiographic unit. It rises from an altitude of 700 feet to 1000 feet at the fault to a height of 3245 feet at Mt. Dromedary in the extreme south-west corner of the area. For a half to one mile south-west of the fault the altitude of the country remains similar to that of the downthrown block but then rises by a series of cliffs and steep slopes to Mr. Dromedary, so that there has been a scarp retreat of about one mile from the fault. Mt. Dromedary is capped by about 1000 feet of dolerite which tends to resist erosion, thus maintaining the relief; however, dolerite and Triassic sediments have been removed east of Mt. Dromedary, revealing the Permian rocks which make up the bulk of the Dromedary block.

Scree slopes, composed mainly of dolerite, are very common between 2800 feet and 2000 feet on the slopes of Mt. Dromedary, but only rarely extend to lower levels. However, at 012428 a tongue of scree material about 200 yards across is found at the stratigraphic level of the Risdon Sandstone at an altitude of 1400 feet. What is probably a

remnant of much older scree material occurs at 027406 in a road cutting near the Upper Dromedary village. It consists of angular blocks of fossiliferous Permian sediments, Triassic sandstones and fresh dolerite with a matrix of finer material of the same composition. The locality lies between the retreated fault scarp and the fault plane, but the position of the material is not consistent with the present-day scarp. However, the material could have been a scree related to an earlier position of the fault scarp.

A distinct, but usually not well developed, bench has formed at the top of the Ferntree Mudstone as a result of its relative resistance to erosion as compared with the overlying Triassic sandstones. At the stratigraphic level of the Rayner Sandstone a similar bench tends to be present.

North and north-east of the Dromedary block the Jordan River flows in a generally south-east direction, roughly parallel to the Dromedary Fault, which has controlled its course. The Jordan River in pre-basaltic times continued in a south-easterly direction as far as Brighton where it turned south to meet the River Derwent. However, owing to basalt filling its valley at least as far west as 087434, the river was displaced northwards so that from near the junction of the Lower Dromedary and Broadmarsh roads it now flows for one and a half miles in a north-easterly direction and then east to Pontville, where it now turns south. For a large part of its course in this portion of the area the Jordan flows in Triassic rocks where it has commonly developed quite extensive terraces.

Soon after the Jordan River enters the north-west corner of the Dromedary square it traverses dolerite in which it has cut a rather steep-sided, V-shaped and gorge-like valley, 500 feet in depth. However, south-west of Strathallie Hill there is a broad open valley in Triassic sediments which extends from Broadmarsh south-east to meet the Jordan valley again near the Broadmarsh-Upper Dromedary turnoff. The reason the Jordan preferred to make its own course in the dolerite, rather than in the softer Triassic sandstones is probably that the drainage pattern is superimposed, since it is thought that the dolerite of Strathallie Hill extended across the broad valley south-west of it to join up with that at 008460. Just east of Broadmarsh the river, in its gorge-like valley, takes a semi-circular course in the dolerite for one and a half miles and then turns south to flow in Triassic sandstones again. On the aerial photographs the river is seen to follow a concentric pattern of joints which formed during the cooling of the dolerite. The course of the river appears to be controlled by these weaknesses within the dolerite, while the dolerite which covered what is now the broad valley to the south-west was eroded off by small creeks. Once the dolerite was removed, erosion proceeded at a faster rate owing to the less cohesive nature of the Triassic rocks, producing the relatively broad valley.

After leaving the gorge north of Strathallie Hill, the River Jordan remains in Triassic sediments to a little south of Pontville where it cuts into basalt which acts as a local base level for the river above it. The stream has cut a steep-sided gorge up to 150 feet deep in the basalt and it remains in this rock type practically all the way to its confluence with the River Derwent. Just south of Brighton the river leaves both the basalt and dolerite and flows in Triassic sandstones and shales, but it soon turns west to run again into basalt. At 120408 the Jordan swings sharply west, then south and then north-east, practically doubling back on itself. After a further swing to the south-east into dolerite the Jordan reaches its estuary about 1000 yards south of the boundary of the Pontville square.

Terraces are commonly developed in the valleys of the major streams of the area, particularly where these streams have Triassic sediments as bed rock. The streams are now almost invariably incised into their terraces although restricted areas of flood plain, which are related to the present river levels, do occur. Several sets of terraces can be recognised. Generally a well-preserved terrace occurs from 5 to 14 feet above the present river levels, while a second slightly dissected terrace is commonly found at the 20 to 40 feet level. This terrace in the Jordan River Valley appears to be degradational, whereas those occurring in the Strathallern and Bagdad Rivulet valleys are covered with alluvium. The latter is well above the level of the basalt and is probably of pre-basaltic age. A possible high level dissected terrace, rising from 40 to 120 feet eastwards, is present east of the Bagdad Rivulet and also appears to be pre-basaltic in age. Since in all cases the terraces are developed behind much more resistant rocks which have acted as local base levels, the rejuvenation indicated by the incised streams cannot be due to eustatic changes in sealevel. This rejuvenation may be caused by climatic factors, e.g., an increase in rainfall resulting in a greater run-off and hence more active stream action. This would have been aided in historical times by the clearing of the land for agricultural purposes which has allowed a faster and greater run-off.

STRATIGRAPHY

A summary of the stratigraphy of the area is set out below:—

Quaternary System: Alluvium and river gravels.
Tertiary System: Mangalore clay deposit; basalt.
Jurassic System: Dolerite.
Triassic System: Granule conglomerates, sandstones and shales; thickness 1000 + feet.
Permian System: Sandstones, mudstones, limestones; thickness 1530 + feet.

PERMIAN SYSTEM

The Permian System, as developed in this area, consists of 1530 feet of sandstones, mudstones, calcareous siltstones and limestones which can be divided into nine stratigraphic units. These have been defined and described in detail by Banks

and Hale (1957), immediately to the south of the area, at Mt. Nassau.

	Thickness (feet)
Ferntree Mudstone	620
Risdon Sandstone	20
"Woodbridge Glacial Formation"	260
Cascades Group—	
Grange Mudstone	0-100
Berriedale Limestone	250
Nassau Siltstone	60
Rayner Sandstone	35
Faulkner Group	40
Bundella Mudstone	250

Their age varies from Lower Artinskian to Kungurian (Banks and Hale, 1957).

Bundella Mudstone

The Bundella Mudstone consists of a series of sandstones, siltstones, mudstones and calcareous mudstones totalling about 250 feet in thickness. Thus some 110 feet more of this formation is exposed in this area than in the type section for the Permian in the Hobart area (Banks and Hale, 1957). The section is very similar in all respects to the type section; there is an upper unfossiliferous member followed downwards by richly fossiliferous beds together totalling some 175 feet. Below this occurs about 40 feet of calcareous mudstone, well exposed at 034402, because of it being hardened by thermal metamorphism caused by an intrusion of dolerite immediately below it. The calcareous nature of the mudstone is due entirely to the fossil content which is of the order of 15 to 20 per cent of the rock. In thin section (8323) the rock is found to be a very poorly sorted mudstone containing about 30% of angular, clear, quartz which ranges in size from 0.8 mm. down to 0.004 mm. or less with an average of about 0.025 mm. The quartz fragments are set in an extremely fine-grained colourless matrix, probably consisting of a mixture of clay minerals and finely divided quartz. Areas of calcite up to 0.5 mm. in length are recrystallized fossils and constitute some 10% of the rock. The mudstone is very fossiliferous containing genera which occur in the upper parts of the formation, such as *Stenopora*, *Strophalosia*, aviculopectenids, spiriferids, fenestellids, *Keeneia platyschismoides* and *Eurydesma*. The lowest exposed unit of the Bundella Mudstone is a massive buff-coloured mudstone about 40 feet in thickness and contains abundant spiriferids and some *Stenopora*.

Faulkner Group

This group consists of about 40 feet of quartz sandstones and siltstones which conformably overlie the Bundella Mudstone and underlie conformably the Rayner Sandstone. Banks and Hale (1957) have defined the Faulkner Group but in this paper, partly due to difficulties in field mapping, the two upper formations, the Fergusson Siltstone and the Altamont Conglomerate, have been included with the overlying Rayner Sandstone.

The thickness of this modified Faulkner Group given by Banks and Hale is 84 feet, which is more than double the thickness recorded in this area. The base of the Faulkner Group is a bed about four feet thick of fine-grained poorly-sorted grey sandstone containing plates of golden mica and abundant black carbonaceous remains. It is composed mainly of quartz with some feldspar. This bed is probably equivalent to the lower part of the Rathbones Sandstone and Siltstone, the Geiss Conglomerate apparently being absent. The rest of the Faulkner Group here consists of grey fissile siltstone and well-sorted massive to flaggy quartz sandstones commonly with much muscovite on the bedding planes. The only member of this group which crops out over any distance is the eight feet thick bed of sandstone, towards the base, which can be correlated with the upper part of the Rathbones Sandstone and Siltstone. The beds above are to be correlated with the Byers Sandstone, Jarvis Siltsone, and the Parramore Sandstone and Siltstone as defined by Banks and Hale.

Rayner Sandstone

The Rayner Sandstone (including the Altamont Conglomerate and Fergusson Siltstone of Banks and Hale) is about 35 feet thick and consists of siltstone and sub-greywacke sandstone. It overlies the Faulkner Group conformably and is in turn overlain by the Nassau Siltstone. At the base occurs a medium-grained yellow sub-greywacke sandstone, which can be correlated with the Altamont Conglomerate because of the numerous sub-rounded erratics present. Its thickness is probably only a few feet. Following this bed is about 20 feet of grey, even-grained, laminated, siltstone, the equivalent of the Fergusson Siltstone. Approximately the upper ten feet of this formation is the Rayner Sandstone *sensu stricto*—a coarse sub-greywacke sandstone containing abundant sub-rounded erratics of low sphericity, composed mainly of vein quartz. The rock is massive, poorly sorted and consists of angular particles of quartz with appreciable amounts of feldspar and small rock fragments. Several spiriferids were observed in the sandstone.

Cascades Group

This group consists of three formations: the Nassau Siltstone, the Berriedale Limestone and the Grange Mudstone, and conformably overlies the Rayner Sandstone and is overlain by the "Woodbridge Glacial Formation". The total thickness is of the order of 310 feet. The Nassau Siltstone was mapped as a separate unit but in most cases it was found impossible to differentiate the upper two formations owing to the lack of outcrop and facies changes from mudstone to limestone.

Nassau Siltstone

The Nassau Siltstone consists of about 60 feet of grey siltstone which becomes quite calcareous towards the top; the boundary between it and the Berriedale Limestone is gradational. The formation in this area is very similar to its equivalent at Mt. Nassau except that the proportion of limestone occurring appears to be much lower in the former. The Nassau Siltstone is composed of a series of alternating massive and fissile siltstones which, when fresh, are grey in colour, weathering to yellow. The basal five feet contains no

fossils and but few erratics; however, above this horizon the proportion of fossils steadily increases, the most abundant fossil being *Strophalosia jukesi*, in addition to spiriferids, ramose *Stenopora*, fenestellids, and some pelecypods and gastropods. Erratics occur throughout the formation but are not abundant.

Berriedale Limestone

The Berriedale Limestone is a massive, dark-grey, dense limestone with beds two to four feet in thickness and two to nine inch beds of laminated calcareous mudstones between them. It is up to about 250 feet thick in this area in contrast to a thickness of some 150 feet given by Banks and Hale for the Mt. Nassau section. As at Mt. Nassau the limestone is very fossiliferous, the most common types being fenestellids, spiriferids, *Stenopora*, both lamellar and ramose varieties and *Strophalosia*. Erratics are present but do not occur abundantly.

Grange Mudstone

This formation is not always present but may be up to 100 feet thick; it is a facies variant of the Berriedale Limestone. Below the "Woodbridge Glacial Formation" at 027419 no Grange Mudstone is present; limestone occurs right up to the basal sandstone of the "Woodbridge Glacial Formation". However, at 006447 about 100 feet of Grange Mudstone is present and a similar thickness occurs at 075400. The Grange Mudstone is a massive buff coloured mudstone containing abundant fossils, including *Strophalosia typica* and very common fenestellids and *Stenopora*. As in the other formations of this group erratics occur but are not common. Banks and Hale report a thickness of about 100 feet for the Grange Mudstone in the Mt. Nassau section which is comparable to the thickness in the Dromedary area but, as pointed out above, in at least one locality no Grange Mudstone occurs.

"Woodbridge Glacial Formation"

Conformably overlying the Cascades Group and overlain conformably by the Risdon Sandstone is the "Woodbridge Glacial Formation", a formation of siltstones and sandstones about 260 feet thick. The section is in all respects quite similar to that at Mt. Nassau, where it is approximately 275 feet thick. The formation is only fossiliferous in the upper 60 feet and the basal 25 feet. The basal member is a coarse-grained sandstone about four feet thick which varies from a reasonably well sorted sandstone at 027419 to a poorly sorted sandstone at 076401, where it contains abundant quartz fragments up to 10 mm. in size in addition to slate fragments. *Strophalosia typica*, as well as other fossils occur in this bed. Above the sandstone there is about 50 feet of alternating sandstone and fissile siltstone; the lower beds of the latter being fossiliferous. The next 140 feet consists of unfossiliferous fissile and massive siltstones and fine sandstones.

The uppermost 60 feet of this formation are siltstones and fine sandstones abounding in fossils, particularly *Strophalosia ovalis*, long-hinged spiriferids and fenestellids. Pelecypods are also common, especially in horizons 20 to 30 feet below the Risdon Sandstone. In a well-exposed section, immediately below the Risdon Sandstone at 067405, an extremely rich fauna was found consisting of abundant *Terrakea* c.f. *solida* and *Strophalosia ovalis*, as well as many other species. Bands in the upper three feet six inches are so fossiliferous as to be called limestones. Erratics are not common through the formation, but locally may be abundant.

Risdon Sandstone

Conformably overlying the "Woodbridge Glacial Formation" and below the Ferntree Mudstone is the Risdon Sandstone, which is about 20 feet thick. Invariably this formation is well exposed, but at only one locality (067405) is the outcrop good enough to obtain a complete section.

The basal member, 6 inches thick, is a conglomerate with a matrix of sand-size particles. The pebbles are composed almost entirely of quartzite and vein quartz and are up to one foot in diameter. Several spiriferids were seen in this bed. Above this occurs five feet of yellow, medium-grained, moderately well sorted, massive quartz sandstone with some feldspar. Towards its base there are some spiriferids present and erratics are by no means rare. A three inch band of iron-stained conglomerate, consisting mainly of sub-rounded pebbles up to six inches in diameter, of quartz and quartzite, occurs above the sandstone. However, many of the pebbles are strongly angular. Some thin, flat, angular mudstone pebbles occur, indicating that water transport was at a minimum. The medium-grained sandy matrix is mainly quartz. The upper 13 feet of this formation consists of a massive, yellow, medium-grained quartz sandstone, showing no bedding (Plate 1, fig. 1). Feldspar, in addition to graphite and muscovite mica are also usually present. The sorting is fair, with fragments of quartz up to 5 mm. in size not uncommon, and there is an occasional small erratic, here and there, through the bed. The total thickness of the formation exposed at this locality is 18 feet 6 inches. Ferntree Mudstone occurs nearby, immediately above the sandstone, but in this section the Ferntree has been removed by erosion. Therefore the thickness of the Risdon Sandstone could be greater than given here, but by no more than a foot or so.

Ferntree Mudstone

The Ferntree Mudstone, conformably overlying the Risdon Sandstone, consists of a series of mottled grey mudstones with subordinate fissile mudstones. It is about 620 feet thick which is very similar to the thickness at Mt. Nassau. On weathering, the rocks assume a yellow colour. In the Mt. Dromedary block the formation commonly has a cliffy outcrop. Erratics are rare, although locally they may be common, but small rock fragments are invariably present in small proportion. Fossils are rare in the Ferntree Mudstone but several spiriferids were observed. Small scale slump structures are not uncommon. In other areas near Hobart a formation of Permian age, the Cygnet Coal Measures, occurs immediately above the Ferntree Mudstone, but if it was deposited in the Dromedary area it must have been removed by erosion before the deposition of the basal Triassic grits.

TRIASSIC SYSTEM

Overlying the Permian System, probably disconformably, occurs a series of sandstones, mudstones and shales with subordinate conglomerates, which from plant remains found in similar beds elsewhere in Tasmania are considered to be Triassic in age (Banks, 1952) and deposited in a terrestrial environment. All the rocks of the Triassic System have been mapped as one unit—the Knocklofty Formation. Two distinct rock associations can be recognised—predominantly sandstone, and sandstone and shale—but it was not possible to divide them off into separate units, for the relationships to one another are not at all clear. The total thickness of the formation is probably about 1000 feet, the basal 650 feet or so of which is mainly sandstone with subordinate shales. Except where the Permian sediments are exposed below the Knocklofty Formation, the position within the sequence is often uncertain since recognisable marker horizons are usually lacking, and there has been much disturbance of the beds by the intrusion of dolerite and the Tertiary faulting. In the main the beds of the Knocklofty Formation are gently dipping (5°-15°) to the south-west but adjacent to faults and dolerite intrusions the direction and magnitude of dip varies considerably.

Wherever the base of the Knocklofty Formation is exposed, 10 to 20 feet of buff to pink conglomerate, granule conglomerate and coarse sandstone occurs. The basal 5 to 10 feet consists of poorly sorted massive conglomerate composed mainly of sub-angular to sub-rounded pebbles of vein quartz up to two inches in diameter. Commonly, bands of conglomerate a few inches thick are separated by beds about one inch thick of coarse quartz sandstone with angular particles. Above the basal congiomerate a granule conglomerate or coarse sandstone occurs, which is also poorly sorted.

Overlying the basal grits are a series of sandstones with subordinate mudstones and shales, which, at Cobb's Hill, are probably at least 650 feet thick. All the Triassic sediments of the Dromedary square are of this type, as well as those of the Pontville-Winton Hill, Shene, Tea Tree valley and Summerville areas in the Pontville square. The sandstone, which is generally yellow in colour and commoniy strongly iron-stained, is medium-grained, massive and well-bedded. Usually the sediments are well sorted and composed mainly of quartz but with significant amounts of feldspar, muscovite mica and graphite. In some beds, particularly at a locality 600 yards north-east of Winton Homestead, marked heavy mineral concentrations occur in the sandstones. Sedimentary structures such as cross-bedding and slumps are very well developed in the sandstone (Plate 1, fig. 2).

Beds of conglomerate up to one inch thick are of fairly general occurrence in the sandstone. They vary from quartz conglomerates with sub-angular to sub-rounded fragments, to clay pellet conglomerates, with all gradations between. The clay pellets are usually flat ellipsoidal bodies up to three inches in diameter which are normally found parallel or sub-parallel to the bedding. In most cases the clay pellets and quartz pebbles are set in a matrix of the same composition and grain size as the surrounding sandstones. The presence of clay pellet conglomerates indicates exposure of the floor and suggests deposition in very shallow water, possibly in a lake.

The mudstones, which are massive to shaly siltstones, are in most cases subordinate to the sandstone. They are buff, purple, pink or green in colour, fine-grained and normally well sorted and almost invariably contain a considerable amount of small muscovite mica flakes. The massive siltstones normally show very fine colour banding parallel to the main bedding. These fine-grained, often laminated, sediments are particularly susceptible to erosion and normally it is only in excavations, cuttings and creek beds that they crop out. As mentioned above, the siltstones are only of a minor importance in the Dromedary square Triassic beds, but in the Pontville square they are not at all uncommon. In the area south of Jew's Hill, abundant shales are present, as revealed particularly in road cuttings, where they are interbedded with fine to medium grained, rather impure, quartz sandstones. On the northern flank of Jew's Hill practically no shale was observed, however. Although there is a fault running along the south-eastern side of this hill, its throw is considered to be only small and it downthrows to the north-east, so that the lack of shale to the north of the hill can only be explained by one, or a combination of two alternatives:

1. They do not outcrop owing to the susceptibility of the shales to erosion; or
2. A facies change occurs from south to the north from sandstone and shale into predominantly sandstone.

The first alternative is preferred, but it is possible that facies variations do play a part.

The Triassic sediments in the floor of the north-west trending Tea Tree Valley are predominantly sandstone. Outside the eastern boundary of the Pontville square, towards the head of the valley at an altitude of 700 feet plus, pink shales and buff siltstones occur with sandstone, and to the north of Maiden Early the Triassic rocks, which are almost completely surrounded by dolerite in plan, are sandstones with a high proportion of shale and siltstone above the 300 foot contour. Lewis (1946, p. 194) reports the presence of plant fragments, probably *Schizoneura* and *Johnstonia*, from this locality. It would appear in this area, therefore, that sandstone and shale overlie the sandstone. Similarly, on the eastern slopes of Elliott's Hill, sandstone and shale, as float, occur.

Wherever reasonable outcrop occurs in the Triassic sediments within the dolerite in the north-east corner of the Pontville square, abundant mudstones and shales are present, interbedded with the sandstone. The maximum thickness of sediments, which are considered to be high up in the Knocklofty Formation, is about 500 feet in this area.

At 157434 on the Tea Tree golf links, a thin sliver of "Feldspathic Sandstone" occurs adjacent to the Bagdad Fault. The rock is a medium-grained moderately well-sorted sandstone containing much feldspar in addition to quartz. Plant remains are present. Evidence from elsewhere in

Tasmania indicates that the "Feldspathic Sandstone" occurs stratigraphically above the Knocklofty Formation.

Thus, above about 20 feet of basal grits, occurs approximately 650 feet of sandstone with shale. However, within this part of the Knocklofty Formation there may be facies variations into a higher proportion of mudstone and shale. The evidence presented above suggests that higher in the sequence mudstone and shale become more abundant and that the total thickness of the formation exceeds 1000 feet in the area. The presence of the sliver of "Feldspathic Sandstone" at 157434 shows that sediments of this higher formation were deposited in the area but most of them have been removed by erosion.

JURASSIC (?) SYSTEM

Large volumes of dolerite intruded as sills, gently transgressive sheets and dykes into the Permo-Triassic rocks, brought to a close the deposition of the sediments of the Triassic System. The age of the dolerite is not known for certain, but it is considered to be Jurassic (Hills and Carey, 1949; Banks, 1952).

In general, the dolerite occurring in the area is a medium to fine grained rock with an even texture and a blue-grey colour when fresh. However, near intrusive contacts, the dolerite becomes very fine-grained, dense and flinty. A thin section (8351) cut from one such rock has an holocrystalline intergranular texture and consists of microphenocrysts of orthopyroxene set in a fine-grained base of granular and prismatic clinopyroxene and laths or anhedral crystals of plagioclase. The bulk of the dolerite is medium-grained and consists essentially of plagioclase laths (usually a labradorite), pyroxene (augite and pigeonite), with an acid mesostasis composed of quartz, plagioclase and alkali feldspar, occurring intersertally. The texture of the dolerite varies from intergranular to truly ophitic.

At one locality (020471) a coarse "pegmatitic" dolerite was found *non in situ* (specimen 8353), and it consists in the main of plagioclase laths (up to 5 mm. in size) and clinopyroxene prisms up to 2 mm. in length with an abundant quartz mesostasis. The texture is hypautomorphic granular. The rock probably originated from the dolerite magma in a late stage of its differentiation.

The dolerite has thermally altered the country rock for only a few feet in most places and generally only hardens the intruded rocks without causing much reconstitution. Thermal metamorphism of Permian sediments generally results in hard, fine-grained cherts in which little or no change in mineral composition has taken place. However, where the dolerite has intruded the Bundella Mudstone, 1000 yards south-east of the Upper Dromedary township, more marked changes have occurred. The calcareous mudstone has become blue in colour and extremely hard near the contact. In thin section (8320) a greater part of the calcite, along with a considerable proportion of the matrix has been transformed into prehnite, so that about 50% of the rock consists of this mineral, which appears to have been produced directly by the thermal metamorphism of the calcareous mudstone. The quartz, which constitutes some 35% of the rock, is fresh and occurs as sub-angular to sub-rounded grains. Its shape is very similar to that in the unmetamorphosed rock (8323). The clastic texture is still quite recognizable.

Baking of the Triassic sediments by dolerite has produced hard, white, sparkling quartzites from sandstones, and dark-blue, extremely hard and fine-grained cherty hornfelses from the quartzose mudstones.

Since the temperature of the dolerite magma was probably about 1000° C., the lack of recrystallization of the intruded sediments for any appreciable distance from the contacts is surprising. However, it is suggested that the reason the contact aureoles are so narrow is because of the absence of a catalyzing fluid being expelled from the crystallizing magma and not to a very limited supply of heat as suggested by Edwards (1942, p. 59). The metamorphism was of the true contact type, the reconstitution which has taken place being due exclusively to heat effects, and the narow aureoles are a result of the poor conductivity of the intruded sediments.

Scattered over the surface of Cornelian Hill (105498) at the north-western corner of the Pontville square, numerous boulders of chalcedony occur, including such varieties as carnelian, agate and hornstone. Layers of prismatic quartz crystals are commonly found between bands of chalcedony. This material is found very closely associated with a dolerite-Triassic sandstone contact. The author is in agreement with Nye (1922, p. 38) in concluding that it is related genetically to the intrusion. It is considered that the silica was introduced by hydrothermal solutions originating from the dolerite at a late stage during the cooling.

TERTIARY SYSTEM

The Brighton Basalts

A large flow of basalt of Tertiary age crops out over some six square miles of the Pontville and Dromedary squares. The flow, which must have been of the order of 200 feet thick, filled the pre-existing valleys of the Bagdad and Strathallern Rivulets and the Jordan River. Except where these rivers have cut down into the basalt the surface has remained practically undissected. The basalt, an olivine-bearing type, varies from a very fine grained dark rock to a medium grained rock with a doleritic texture. The Brighton Basalts will be dealt with in more detail in a separate paper.

The Mangalore Clay Deposit

Occurring above, and extending northwards from the basalt in the Bagdad Rivulet valley are a series of poorly consolidated clay and sand beds. Up to five feet of them, consisting predominantly of clay, are exposed where the rivulet has cut down through the terrace. Some of the clay appears to have been produced by weathering of basalt *in situ* but the bulk of the clay has probably been transported. The extent of the deposit has not been determined, but it is possible

that the clay and sand beds are present under the extensive terrace stretching to the north in the Mangalore area. This material was probably deposited in a lake dammed behind the basalt which flowed up the Bagdad Rivulet valley.

D. P. Bahl has determined a sample of the clay by means of X-ray diffraction powder photographs and differential thermal analysis, and finds it to be a mixture of kaolinite and an abnormal montmorillonite, each making up about 40% of the sample with the remaining 20% quartz.

QUATERNARY SYSTEM

The greater part of the gravel, sand and silt deposits of the terraces, including the cover of alluvium in the present river valleys, are considered to belong to this system. On the maps, it has only been found possible to show these deposits where there is no interference with other geological boundaries. The sections through the terraces, exposed by the streams which have been incised into them, show that there is a great variation in composition. Some sections consist mainly of river gravels, covered by a thin layer of alluvium, while others have a fairly high proportion of sands, silts and clays. The river gravels are composed mainly of dolerite cobbles up to about one foot in size which are generally sub-rounded, although platy joint blocks of dolerite are not at all uncommon. The river gravel deposits have, in many cases, a well developed imbricate structure and they are generally moderately well consolidated with a matrix of sand and some finer material. Sand and silty lenses occur but in general they only constitute a small proportion of the terraces, although locally six to eight feet of them may be exposed. Extensive areas of the valley floors are covered by a thin veneer of dark-coloured alluvium deposited by the streams.

STRUCTURE

Faulting

Faulting, which is considered to be Lower Tertiary in age (Hills and Carey, 1949, p. 35), has been of considerable magnitude, particularly in the south and south-west portion of the Dromedary square. The faults are normal with the planes close to vertical, but sharp changes in their trend are not uncommon. The strike of the faults is in general north to north-west. Figure 1 is a diagrammatic map of the fault system.

The major fault of the area is the Dromedary Fault, striking in a generally north-north-west direction across the south-western portion of the Dromedary square. This fault and the faults of the adjacent horst blocks are the continuation northwards of the Cascade Fault system recognised in the Hobart area.

The Dromedary Fault upthrows to the south-west, bringing beds low in the Bundella Mudstone up against dolerite intruded into Triassic sandstones so that the throw is greater than the thickness of the Permian succession, i.e., 1500 feet +.

Further east in the Cobb's Hill horst there is at least 600 feet of Triassic strata above the Ferntree Mudstone without dolerite intruded into it, so that the throw on the Dromedary Fault is probably 2200 feet or more. Along the fault from 027437 in a north-westerly direction the throw decreases and, because dolerite becomes transgressive down into Ferntree Mudstone the fault becomes difficult to trace into the adjacent square, Black Hills. Furthermore, the main fault divides up into several smaller faults, all still with the same sense of movement. The physiographic expression of the fault is a series of gullies and saddles which can readily be traced on the aerial photographs. As mentioned previously, the downthrown block is

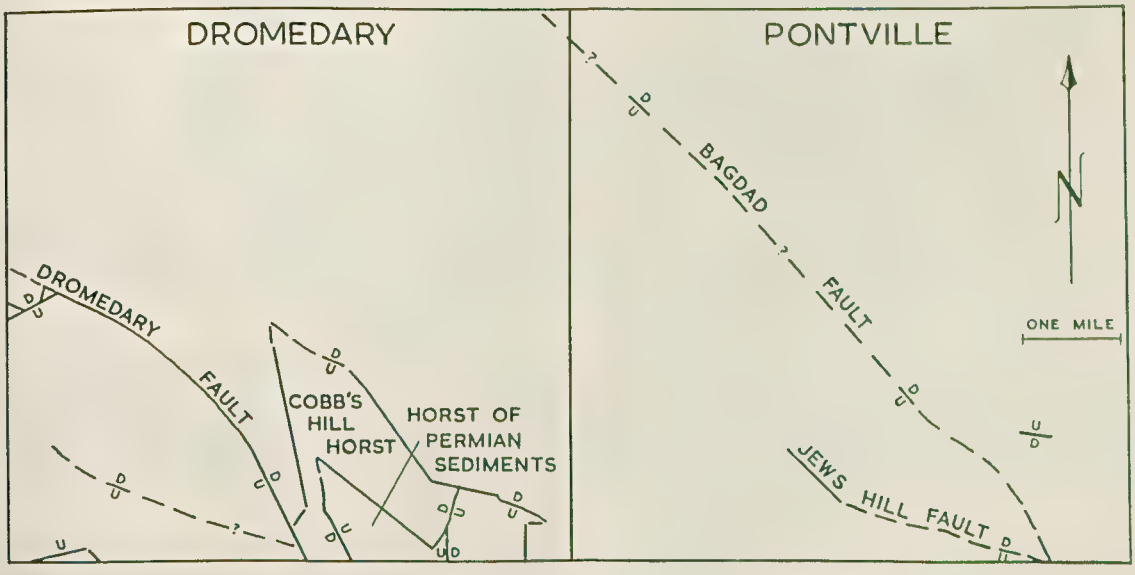

FIG. 1.—Diagrammatic map of the fault system of the Dromedary-Pontville area.

tilted towards the fault plane producing a fault angle depression—a common feature of tension faulting, and this may be caused by the fault plane becoming less steep at depth. Within the upthrown Dromedary block several faults of a throw of about 100 feet have been recognised. In general, they strike in towards the Dromedary Fault. At 010401 in a road on the line of one such fault, a very hard fault breccia some sixteen yards in width is exposed. This consists of strongly angular Permian mudstone fragments up to several inches in size.

There are two horsts in the south-eastern portion of the Dromedary square. The larger one, the Cobb's Hill horst, consists of Triassic sediments, which have been upfaulted, as indicated by drag dips, into dolerite intrusive into the Knocklofty Formation. At Cobb's Hill basal Triassic grits occur at 077404 with some 600 feet of sandstone (and some shale) above them. There is no sign of dolerite in the section, so that the dolerite intrusive into the Knocklofty Formation north of the horst fault is most probably in horizons at least 650 feet above the base of the Triassic sediments. The horst fault therefore has a throw of at least 650 feet and it could be as much as 900 feet. The western boundary fault of the horst joins up with the Dromedary Fault resulting in a decrease in throw along this fault of the order of 900 feet.

The second horst, consisting of Permian sediments, occurs within the Cobb's Hill horst and it is remarkable that the shape of this block is very similar to that of the surrounding horst. At 075403 the throw of the boundary fault is about 900 feet and this throw possibly remains constant. The faults of this block disappear into the Derwent River to the south. From 078405 to 080444 a fault with a north-north-east trend joins the two systems of horst faults resulting in Ferntree Mudstone being upthrown against Knocklofty Formation on the west and dolerite on the north and east. The throw is probably about 500 feet.

At 048434 a floater of hard white quartzite was found near the Knocklofty Formation-dolerite boundary, suggesting the possibility of an intrusive contact. However, no other definite contact effects were observed and the boundary is most probably a Tertiary fault, as has been assumed above, the quartzite having been brought up by the faulting from an intrusive contact below.

The Jews Hill Fault strikes in a generally west-north-west direction along the south-western flank of the hill and the drag dips on the Triassic sandstones and shales indicate that the south-west side is upthrown. The throw on the fault at a minimum is 150 feet, but it is probably somewhat greater than this. The dolerite overlying the sediments on the upthrown side has been removed by erosion. The fault can be traced with minor inflexions in an east-south-easterly direction at least as far as the southern boundary of the Pontville square, but it cannot be found extending towards Brighton from the western slopes of Jew's Hill.

The dolerite-Knocklofty Formation boundary trending north-west along the western side of Thompson's Hill appears to be a fault—called here the Bagdad Fault. At 153436, in a cutting on the Tea Tree road, sandstones which have a dip of 20° to the north-east are exposed and this has been interpreted as drag dip on a fault with the east side downthrown. At the top of Thompson's Hill several feet of white, glassy quartzite occurs overlying the dolerite, and it is suggested that this is a remnant of the roof rocks of the Jews Hill intrusion, which has been faulted down to its present position. Nevertheless it is possible that the quartzite may have been a small raft of sediment floating within the dolerite. On the hypothesis that the baked sediment is in fact a portion of the roof rocks of the Jews Hill body, a throw on the fault of some 800 to 1000 feet is required, downthrowing to the east. In a trench (157434) on the line of the postulated fault a thin sliver of "Feldspathic Sandstone" occurs. Its boundary with the dolerite is much shattered and there is much lime present. All these facts taken together suggest the existence of a fault. Lewis (1946, p. 185) interprets the dolerite-Triassic contact at Thompson's Hill as intrusive because of the strong baking along the dolerite-sediment contact running south from 168423; this point lying on the fault. However, on p. 196 Lewis states that at the Tea Tree golf links, near the Tea Tree road, the contact appears to be faulted.

It is significant that the axis of the pre-basaltic valley and also of the present-day valley is a continuation of the Bagdad Fault. Between the Wybra Hall Permian rocks and the Triassic sediments at Shene the fault explains the lack of stratigraphical rank across the valley; however, the extension of this fault further north is somewhat doubtful. It could cut across the extreme north-eastern corner of the Dromedary square, dropping the Knocklofty Formation down to dolerite, which further south is intruded into Ferntree Mudstone, but there is some doubt since several blocks of thermally metamorphosed sandstone were observed near the boundary, suggesting rather that the contact is an intrusive one.

The relatively high country rising westwards from the main Hobart-Launceston Highway from Pontville north must be considered, therefore, as a dissected, retreated fault scarp with the Bagdad Rivulet formed in the fault angle; the highlands rising to the east possibly being the result of tilt of the downthrown block in towards the fault. The Bagdad Fault could be continued southwards approximately along the axis of the Back Tea Tree Valley, but dolerite occurs both east and west of the proposed line so that there is no proof for its existence in this area.

A fault with a throw of the order of 100 feet was recognised at 185423, south of Elliott's Hill, striking just north of west. The Triassic sandstones have a strong dip (40°) to the south, indicating that the northern side is upthrown. The displacement of the dolerite contact westwards on the upthrown side of the fault supports the view that the floor of the intrusion dips towards the west.

At 027461 the reversals of dip and the relatively high angles of dip recorded in the Triassic sandstones probably indicate a fault passing through

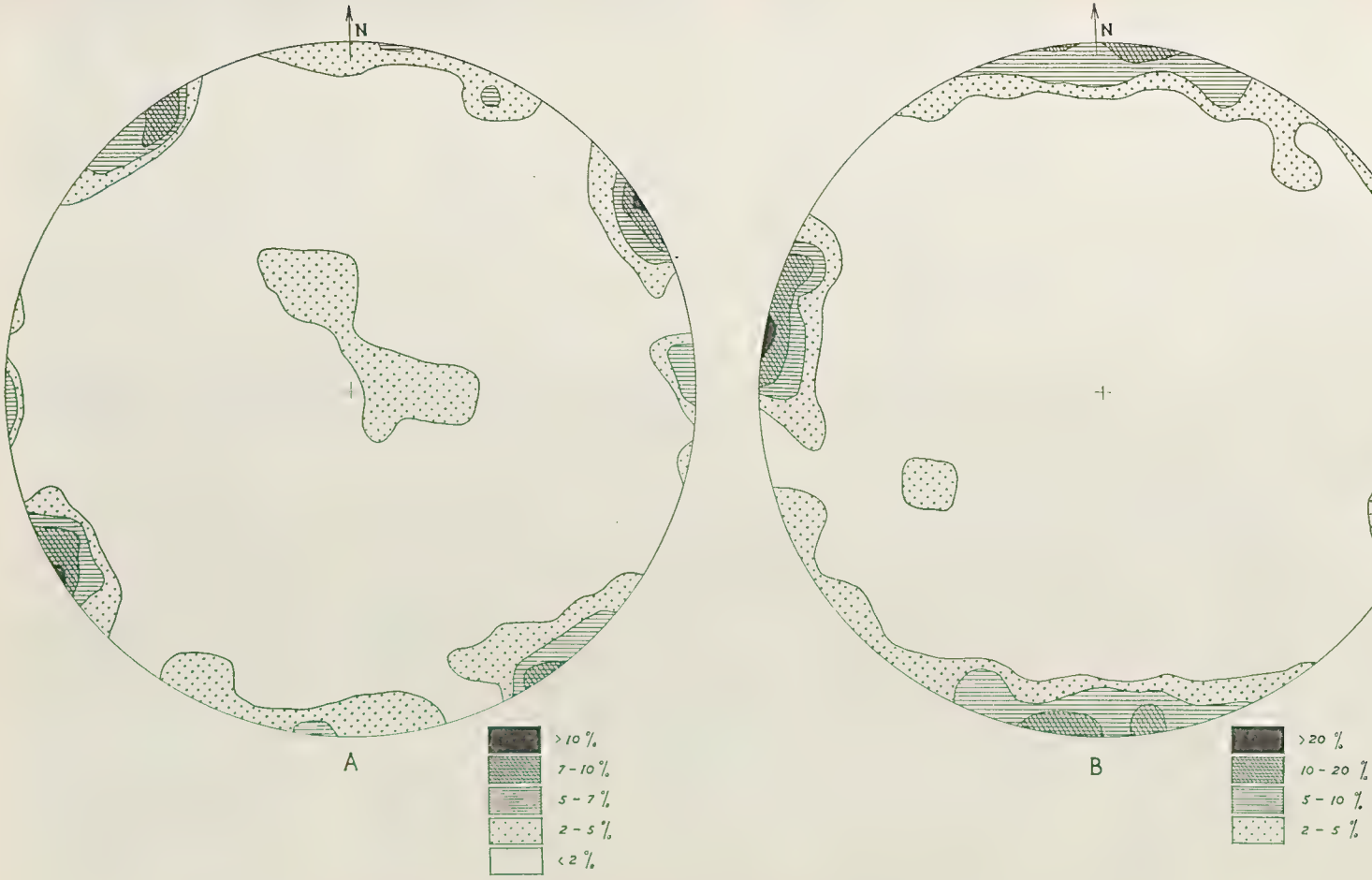

FIG. 2.—A. Contoured stereographic projection of the poles to 70 joint planes in dolerite.
B. Similar pojection for poles to 45 joint planes in sediments.

the area, but it was impossible to obtain a consistent picture of the movement from the dips nor could a fault be traced in the area.

Jointing of the Dolerite

Jointing is very well developed in much of the dolerite and up to five different directions have been observed in the one exposure. In many outcrops there is a predominant series of joint planes, which, in general, are sub-vertical and closely spaced so that thin plates an inch or so in thickness are frequently found. Columnar jointing is rarely developed. In some places it has been observed that the strike of one joint system approximates to the trend of the dolerite-sediment contact, but this is by no means apparent everywhere.

The poles to seventy joint planes in the dolerite were plotted on a stereogram (Fig. 2*a*) which was then contoured. A maximum of 10% occurs in a direction of 55°, corresponding to a set of vertical joints striking at 325°, and at right angles to this a 7% maximum occurs corresponding to vertical joints striking at 55°. Sub-maxima (5%) occur in an east-west and north-south direction representing vertical joints striking north-south and east-west respectively. Sub-horizontal joints are not uncommon, as shown by the presence of a 2 to 5% area towards the centre of the diagram.

Both the trend of the Tertiary faults and the strike of the most strongly developed system of joints is the same. The other main set of joints is at right angles to the trend of the faults. The coincidence of direction may be purely fortuitous, or the two prominent sets of joints may be related to the tensional forces which produced the faults or it might even be possible that the Tertiary faults were controlled by the joint directions in the dolerite.

If the joints in the dolerite were produced at the same time as the Tertiary faulting, it might be expected that the sediments also would show such joints. A contoured stereographic projection of the poles to the joint surfaces, mainly in Permian rocks, was prepared (Fig. 2*b*) and two good maxima occur at 100° and 10°, corresponding to two sets of vertical joints striking at 10° and 100° respectively. Although only 45 readings were obtained, the maximum of nearly 25% is probably significant. These two directions do not correspond to those in the dolerite nor to the general trend of the Tertiary faults.

THE FORM OF THE DOLERITE INTRUSIONS

Dolerite occupies more than a third of the area and, except within the horsts and the Dromedary fault block, the hills are almost invariably capped by dolerite. It is intrusive into both Permian and Triassic sediments, but by far the greater volume is found in the latter beds in this area. The form of intrusion is extremely variable, from concordant or slightly transgressive sheets to strongly transgressive dyke-like bodies. Sill-like bodies of dolerite are most common, although in detail the contacts are in many cases discordant. The thicknesses of the sills are usually impossible to determine since the sedimentary roof rocks of the intrusions have generally been removed, but in most cases at least 500 feet of dolerite is exposed, and at Mt. Dromedary there appears to be about 1000 feet.

The large mass of dolerite extending north of Strathallie Hill has strongly discordant contacts with the country rocks. Along the southern side of Strathallie Hill a sliver of much shattered and strongly thermally metamorphosed Ferntree Mudstone up to 200 yards wide and one mile long crops out at a higher altitude than adjacent Triassic sediments. It is interpreted as being due to dragging up along the dolerite contact by the forcible intrusion of the dolerite. This, along with the roughly-concentric pattern of joints, one of which the Jordan River follows for some distance, suggests the possibility of a centre of intrusion in this area.

Eastwards from this centre a sill-like body of dolerite was intruded into the Ferntree Mudstone and the lower beds of the Knocklofty Formation, lifting the large block of Mangalore sediments above it. The dolerite is generally concordant but in local areas it is slightly transgressive, since it rises stratigraphically towards the north through the Ferntree Mudstone into the basal beds of the Knocklofty Formation. North of the Mangalore Creek, near the northern boundary of the Dromedary square, two blocks of Ferntree Mudstone occur floating as rafts in the dolerite, and these are probably remnants of the sedimentary cover of the intrusion, separated from the main body of roof rocks by dykes of dolerite.

The block of Ferntree Mudstone half a mile long and up to three hundred yards wide cropping out half a mile north of the turn-off to Mangalore on the Broadmarsh road, is also a portion of the roof rocks overlying the dolerite. Towards the east the dolerite invaded lower in the Ferntree Mudstone till near the base of the latter it became dyke-like, the contact running in a straight line down through the "Woodbridge Glacial Formation," north of Wybra Hall, to be cut off by the inferred Bagdad Fault from the Triassic sediments further east. North and north-west of the Mangalore Creek Valley the hills, which consist of dolerite, rise rather steeply to about 1000 feet so that the lack of sediments above the dolerite here indicates that it became more transgressive northwards.

Dolerite connected with the Strathallie Hill intrusion and the sill underlying the Mangalore Creek sediments rose up through an east-west fracture into the Knocklofty Formation, where it spread southwards as a sill. The dyke-like contact runs along the northern flank of the Winton Hill-Goat Hill ridge, which consists of the eroded dolerite sill. The Mangalore Creek sediments are therefore in a large block (four miles long and averaging one mile in width), isolated from the sedimentary basement by dolerite. Lewis (1946, p. 191) explained the occurrence of the Mangalore Permo-Triassic block as being due to faulting along east-west lines before the intrusion of the dolerite, but this is incorrect—the faulting was cognate with the intrusion. On the southern slopes of Winton Hill the dolerite becomes transgressive down through the Triassic beds.

In the extreme north-eastern corner of the Dromedary square the dolerite is possibly faulted up against Triassic sediments along the postulated Bagdad Fault, but the presence of some quartzite suggests that the boundary is in fact intrusive. If the contact is an intrusive one the dolerite would have to be strongly transgressive upwards, since the field relations indicate that the Triassic beds would have to constitute the floor of the intrusion.

The dolerite extending from Lodge Hill westwards to the western edge of the Dromedary square is considered to be the southern continuation of the Goat Hill-Winton Hill sill, the Jordan River having cut down through it to reveal the underlying Knocklofty Formation. The dolerite remains sill-like for the most part, except in the area between the Broadmarsh road, south-west of the Mangalore turn-off, and the Dromedary Fault where the dolerite has discordant contacts with the intruded sediments. This dolerite sill is faulted off on the south and south-west by the Dromedary Fault and the Cobb's Hill horst faults. An irregularly-shaped block of Triassic sandstone and shale, completely surrounded by dolerite, except on one side which is faulted off by the Dromedary Fault, occurs in the area around 040435. The contacts are discordant and the sediments are strongly thermally metamorphosed. It is uncertain whether this block is a raft of sediment in the dolerite or is connected with the country rock below the dolerite. A similar type of occurrence is found at 087412.

The small dolerite body at Brighton and the two masses south, on the eastern side of the River Jordan, are considered to be extensions of the Lodge Hill dolerite.

The dolerite capping Mt. Dromedary was intruded at least 400 feet above the base of the Triassic beds which, at 007404 on the south-eastern slopes of the mountain, is at an altitude of 1830 feet. The dolerite intrusion appears to be a flatlying sill so that its exposed thickness is of the order of 1000 feet, since the altitude of Mt. Dromedary is 3245 feet. It is considered to be the same sill as that exposed in the downthrown side of the Dromedary Fault. Within the Dromedary block dolerite has also been intruded, as a sill, 100 to 250 feet below the top of the Bundeila Mudstone. Since dolerite occurs in the lower Permian sediments immediately adjacent to the Dromedary Fault and also in the downthrown block right up to the fault plane, intruded into Triassic strata, then there are at least two bodies of dolerite at different stratigraphic horizons in this part of the area.

In the north-western corner of the Dromedary block dolerite has been intruded into Ferntree Mudstone; three of the four boundaries are Tertiary faults but the fourth is a dyke-like dolerite chilled contact.

West of the Strathallie Hill intrusion and divided from it by the Broadmarsh Valley in sandstone is an arrowhead-shaped, dyke-like intrusion of dolerite which may be an extension of the Strathallie Hill body from depth. It is definitely connected with large intrusions to the north and west.

Jews Hill consists of a sill of dolerite intruded into Triassic sediments and it has a fault running along its southern flank. The northern boundary is approximately concordant, but the base of the dolerite rises eastwards from 250 feet on the western side of the hill to about 680 feet at 165418, east of which it decreases by 200 feet in 500 yards. The dolerite, becoming strongly transgressive, swings north to meet the Bagdad Fault 400 yards south of Thompson's Hill. At least 600 feet of dolerite is exposed on Jews Hill. The Thompson's Hill-Elliott's Hill intrusion is considered to be the same sill faulted down some 800 feet by the Bagdad Fault with the baked Triassic sandstone on top of Thompson's Hill possibly a remnant of the roof sediments; however, the quartzite here could well be a small raft in the dolerite. The base of the sill is exposed on the eastern slopes of Elliott's Hill and strikes in a south-easterly direction. The contact is in general concordant but, northwards from 181428, it is dyke-like.

The three-quarter mile wide Tea Tree Valley, eroded in sandstone, separates the Elliott's Hill dolerite from another intrusion, which has the same general trend and which is part of the large mass of dolerite in the north-eastern portion of the square. This large and extensive intrusion of dolerite remains in the Knocklofty Formation, but becomes higher stratigraphically towards the north-east. There are many blocks of sediment which, in plan, are completely surrounded by dolerite; their diameters range from 100 yards to half a mile. In many cases these appear to be rafts of sediment, floating in the dolerite, which were torn off from the country rocks by the invading magma.

South-east of Tea Tree the dolerite contact with the country rocks is steeply dipping, but north of Tea Tree it becomes concordant, with the dolerite overlying the sediments. Dolerite extends eastwards to the edge of the square from this contact probably in the form of a flat dipping sheet. North of Maiden Early the dolerite remains concordant, except in the area around 158468, where it becomes strongly transgressive. The south-west striking spur of dolerite north-west of Maiden Early is probably continuous with that extending north from Thompson's and Elliott's Hills under the basalt. The contact with the Knocklofty Formation on the northern side of the spur rises gently towards the north-east and then swings to the north-west, striking in this direction to the boundary of the Pontville square. The steep dips to the south-west (e.g., 52° at 120497) and the strong thermal metamorphism suggests a transgressive body rising to the north-east, but whether this discordance continues to any great depth is uncertain.

A large intrusion of dolerite occurs in the north-east corner of the Pontville square. This contains large blocks of Triassic sediment and these are probably the key to the form of the intrusion, but several interpretations are possible. If the base of the dolerite rises towards the north-east then these blocks could be part of the sedimentary floor exposed by erosion. The base of the dolerite one mile north-east of Shene is at about 350 feet, but the Triassic-dolerite contact one mile further north-east at 163495 is at 1400 feet so that a gradient of one in four is required on the base of the dolerite for it to reach this height. However,

the contact 500 yards north of Sheehan's Hill is only at about 970 feet so that a gradient of only one in seven is necessary here. Since the dolerite nearly surrounds the blocks of Triassic sediments the base of the dolerite would have to be very irregular to explain the field data by this form of intrusion. By means of faults, one along each of the two creeks which join one mile north of Merriworth, it is possible to explain the presence of Triassic rocks on the western slopes of both valleys, but since no major fault is present further south the throws on the two faults would have to decrease southwards. The sum of the throws (which are in the same sense) must be only several hundred feet where the two faults meet. The Mt. Dismal block between the two postulated faults would have to be tilted towards the south-west to produce such a system of faults and there would have also to have been several hundred feet of downward movement of the eastern block at the edge of the square with respect to the dolerite in the Sheehan's Hill area. The large blocks of Triassic sediments are still not adequately explained by this hypothesis.

A single sill-like body, which has not been faulted at a later time and which, during its intrusion, detached blocks of sediment from the country rock so that they remained floating in the dolerite, may possibly explain the field facts. But many intrusions of dolerite are found free of such rafts of sediment so that if this interpretation is correct there must be some controlling factor on this intrustion which is not normally operative. S. W. Carey (personal communication) suggested that if dolerite magma from two different centres of intrusion were to interfinger, then an outcrop pattern as found in this area may result. Blocks of sediment would be isolated from the country rock in such a zone of interfingering. This last hypothesis, at the present time, appears the most reasonable interpretation, but it is considered that the relationships between the dolerite and the intruded sediments, in this part of the area, will only become clear when further detailed mapping is carried out in adjacent areas.

A small oval-shaped intrusion of dolerite, 300 yards by 200 yards, occurs 200 yards south-east of the junction of the Bagdad Rivulet with the Jordan River. It is a plug-like mass which is, however, conformable for a short distance on its eastern margin.

SUMMARY

A sequence of over 1500 feet of mainly marine sandstones, mudstones, siltstones and limestones was deposited during Permian times followed disconformably by at least 1000 feet of Triassic terrestrial sandstones and shales. In the Jurassic (?) Period there were great intrusions of dolerite into the Permian and Triassic sediments in the form of dykes, slightly transgressive sheets and sills. Strong Tertiary faulting affected the area, particularly in the south-western portion of it, and this, along with the distribution of rock types, has been a controlling factor in the formation of the present-day physiography. Basalt, probably of Upper Tertiary age, partly filled the valleys of the Jordan River and its tributaries.

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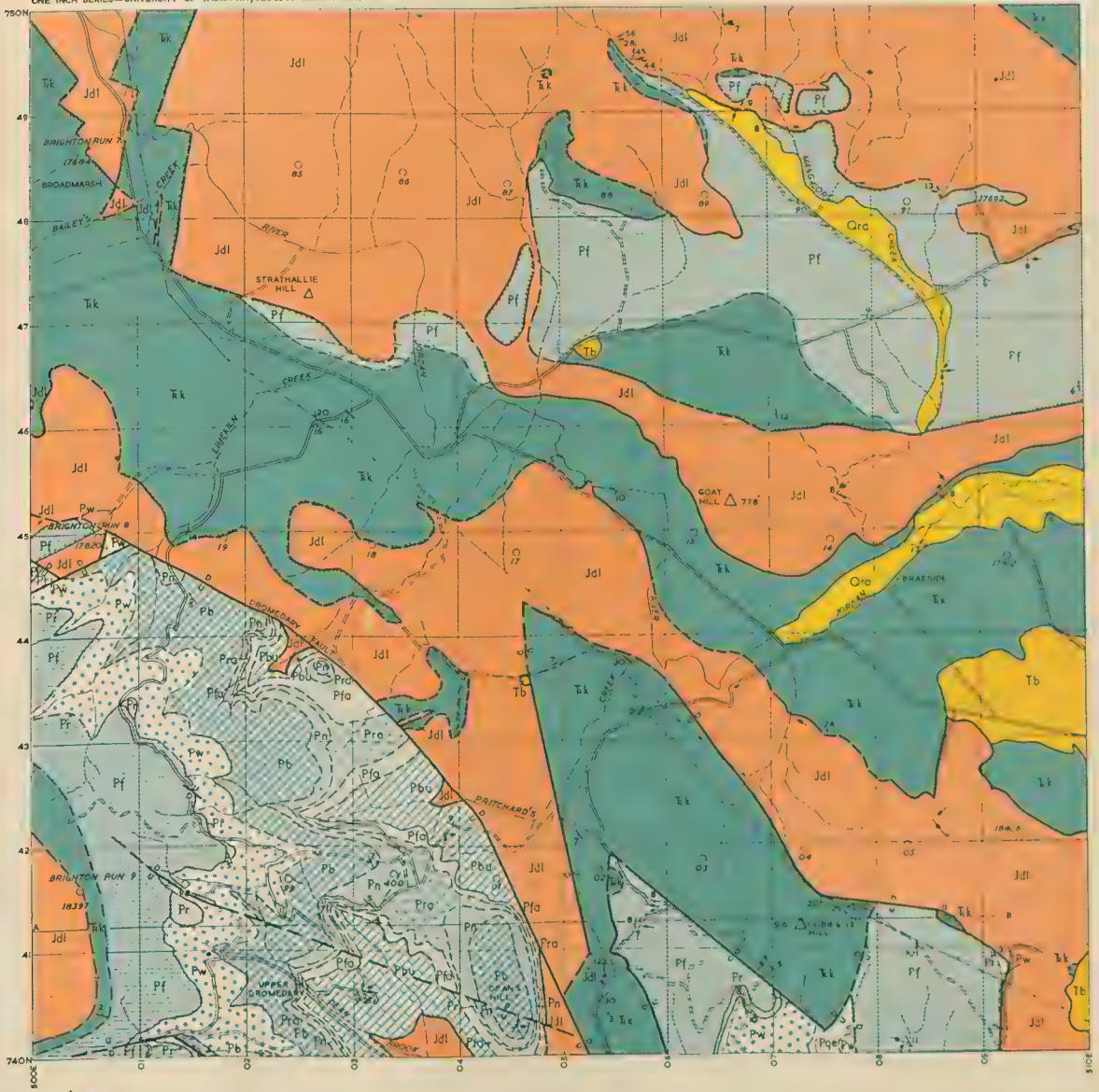
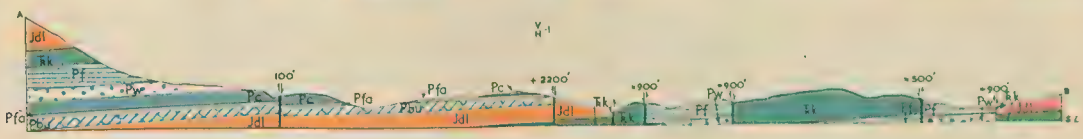
Plate 1.

Fig. 1.—Typical outcrop of massive Risdon Sandstone on the Upper Dromedary road.
Fig. 2.—Triassic quartz sandstone showing well-developed current bedding and slump structures.

DROMEDARY





LEGEND

Quaternary System
RECENT SERIES
- Qra — ALLUVIUM

Triassic System
- Tk — KNOCKLOFTY FORMATION

Permian System
- Pf — FERNTREE MUDSTONE
- Pr — RISDON SANDSTONE
- Pw — WOODBRIDGE GLACIAL FORMATION
- Pge — GRANGE MUDSTONE
- Pc — CASCADES GROUP: BERRIEDALE LIMESTONE
- Pn — CASCADES GROUP: NASSAU SILTSTONE
- Pro — RAYNER SANDSTONE
- Pfa — FAULKNER GROUP
- Pbu — BUNDELLA MUDSTONE

IGNEOUS ROCKS
Tertiary System
- Tb — BASALT

Jurassic(?) System
- Jdl — DOLERITE

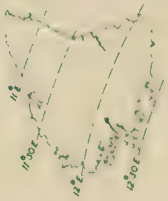
- FAULT WITH DOWNTHROWN SIDE INDICATED
- FAULT—POSITION APPROXIMATE
- FAULT INFERRED
- FORMATION BOUNDARY
- FORMATION BOUNDARY—POSITION APPROXIMATE

Dolerite Boundaries
- CONCORDANT SILL
- DISCORDANT INTRUSIVE BOUNDARIES

- VERTICAL JOINTS
- STRIKE AND DIP OF JOINTS
- STRIKE AND DIP OF STRATA
- ROAD
- RAILWAY LINE
- VEHICULAR TRACK
- TRANSMISSION LINE

Compilation from Aerial Photographs
Trigonometric Station Control by courtesy of the Department of Lands and Surveys Hobart and the Australian Army Survey Service
Origin of co-ordinates 400,000 yds. West and 1,800,000 yds South of the True Origin of Zone 7 of the International Grid.

KEY MAP SHOWING MAGNETIC DECLINATIONS SECULAR VARIATION 7 MINS. P.A.



MAPPED AND COMPILED BY I. McDOUGALL 1958

SCALE
1 2 MILES
0 1 2 3 4 5,000 10,000 FEET

GEOLOGY OF THE DROMEDARY AREA
SHEET 5074

PHYSIOGRAPHY

The area has in general a relief of about 800', with rounded, but commonly steep-sided, hills rising up from relatively broad valleys. The physiography has been controlled mainly by the Tertiary faulting striking in a north-westerly direction. The Dromedary Fault is the major fracture and has a throw of 2,000 feet or more decreasing in magnitude to the north-west. On the upthrown (south-west) side of this fault the relief is in excess of 2,000'. In the downthrown block, which was tilted towards the fault plane, the main drainage of the area takes place parallel to the fault with small consequent streams flowing in at approximately right angles from both blocks. The distribution of the resistant dolerite and the relatively soft sediments has also been an important factor in controlling the physiography. The Jordan River north of Strathallie Hill, has cut a steep-sided valley and appears to follow major joints within the dyke-like intrusion of dolerite.

STRUCTURAL GEOLOGY

The major structural features are the Tertiary faults. Apart from the large Dromedary Fault two horsts occur within the southern part of the area with the larger Cobb's Hill horst of Triassic sediments having a throw of the order of 900', and the inner, smaller horst, consisting of Permian sediments, having a throw of similar magnitude.

STRATIGRAPHIC TABLE

Age	Group	Formation	Lithology	Thickness (in feet)
Quaternary			River gravels and alluvium	
Tertiary		Brighton Basalt	Olivine basalt flow	100
			Basanite plugs	
Early Tertiary (?)			Strong Faulting	
Jurassic (?)			Tholeiitic dolerite sills and dykes	
Triassic		Knocklofty Sandstone and Shale	Predominantly quartz sandstone, some shale. Basal conglomerates and granule conglomerates.	650
Permian		Ferntree Mudstone	Mudstone	620
		Risdon Sandstone	Sandstone, conglomeratic bands	20
		"Woodbridge Glacial Formation"	Siltstones and fine sandstones—Basal coarse sandstone	260
	Cascades	Grange Mudstone	Mudstone	100-0
		Berriedale Limestone	Limestone, minor calcareous mudstone	150-250
		Nassau Siltstone	Siltstone	60
		Rayner Sandstone	Sandstone and Siltstone	35
	Faulkner		Sandstone and Siltstone	40
		Bundella Mudstone	Sandstones, siltstones, mudstones	250+

IGNEOUS ROCKS

In the Jurassic (?) Period there was widespread injection by tholeiitic dolerite magma into the Permo-Triassic sediments as large, commonly irregular, sill-like and dyke-like bodies. The sills in most cases have been unroofed by erosion. Over 1,000 feet of dolerite is exposed in a sill capping Mt. Dromedary in the south-west corner of the area.

There are two occurrences of basanite in the form of plugs and these are considered to be Tertiary in age. A flow of olivine basalt of Tertiary age fills portion of the pre-basaltic Jordan valley.

POINTS OF SPECIAL INTEREST

Basanite plug (5053E 7468N).
Horst fault (5060E 7415N).
Dromedary Fault (5047E 7413N).
Fault breccia (5010E 7402N).
Steep intrusive contact of dolerite with sediments (5050E 7466N).
Basal Triassic grits (5070E 7472N).
Risdon Sandstone (5067E 7405N).

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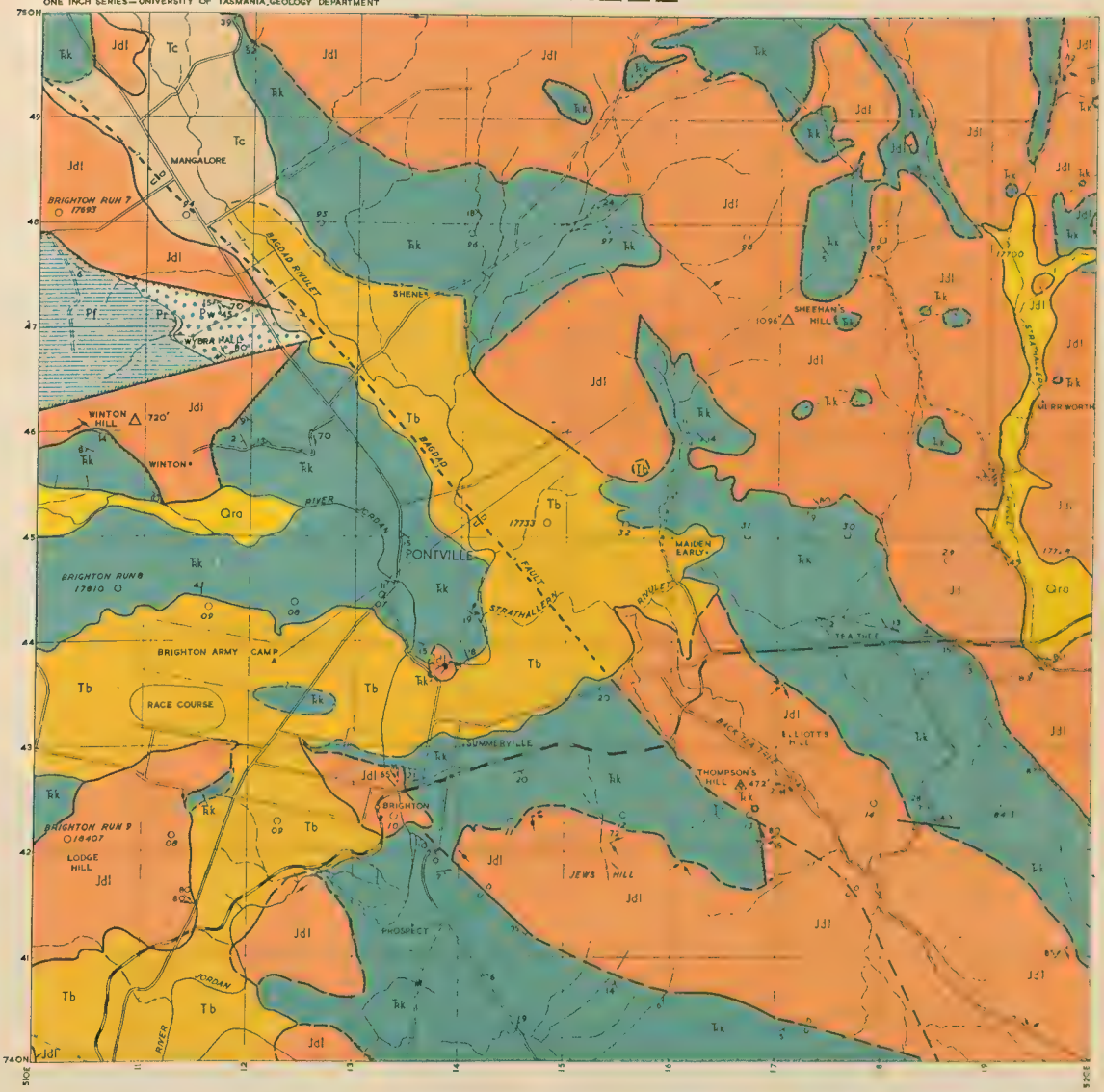
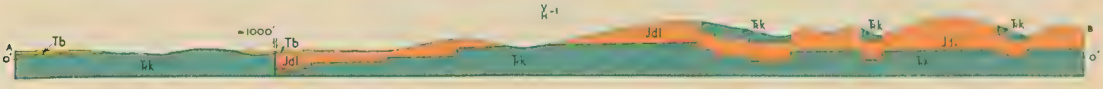
GEOLOGY OF TASMANIA

ONE INCH SERIES—UNIVERSITY OF TASMANIA, GEOLOGY DEPARTMENT

PONTVILLE





LEGEND

- FAULT WITH DOWNTHROWN SIDE INDICATED
- FAULT CONCEALED
- FAULT INFERRED
- FORMATION BOUNDARY
- FORMATION BOUNDARY – POSITION APPROXIMATE

Dolerite Boundaries

- CONCORDANT SILL
- DISCORDANT INTRUSIVE BOUNDARIES
- VERTICAL JOINTS
- STRIKE AND DIP OF JOINTS
- STRIKE AND DIP OF STRATA
- ROAD
- RAILWAY LINE
- VEHICULAR TRACK
- TRANSMISSION LINE

Quaternary System
RECENT SERIES
- Qra ALLUVIUM

Tertiary System
- Tc CLAYS AND SANDS

Triassic System
- Tk KNOCKLOFTY FORMATION

Permian System
- Pf FERNTREE MUDSTONE
- Pr RISDON SANDSTONE
- Pw WOODBRIDGE GLACIAL FORMATION

IGNEOUS ROCKS
Tertiary System
- Tb BASALT

Jurassic ? System
- Jdl DOLERITE

Compilation from Aerial Photographs
Trigonometric Station Control by courtesy of the Department of Lands and Surveys, Hobart, and the Australian Army Survey Service
Origin of co-ordinates 400,000 yds West and 1,800,000 yds. South of True Origin of Zone 7 of the International Grid

KEY MAP SHOWING MAGNETIC DECLINATIONS 1957
SECULAR VARIATION 7' PER ANNUM

MAPPED AND COMPILED BY I. McDOUGALL 1956

SCALE
0 1 2 3 4 5 MILES
0 5,000 10,000 FEET

GEOLOGY OF THE PONTVILLE AREA
SHEET 5174

PHYSIOGRAPHY

Rounded but steep-sided hills, usually composed of dolerite, rise up to some 800' above the broad open valleys which are generally eroded in the relatively soft Triassic sediments. Faulting has also been a controlling factor, particularly the Bagdad Fault, which the Bagdad Rivulet follows for some distance. Commonly dolerite and basalt act as local base levels for the streams because of their resistance to erosion. Above these bars the drainage system has sediments as bed rock and wide valleys have been eroded in which the gradient of the streams is low. Within the basalt and dolerite the rivers have developed gorges.

The surface of the basalt, except where the streams breach it, is markedly planar.

STRUCTURAL GEOLOGY

The Bagdad Fault is the main structural feature of the area and has an estimated throw of about 800', downthrowing to the north-east. The south side of Jew's Hill is also faulted, with a minimum throw of 150'.

STRATIGRAPHIC TABLE

Age	Formation	Lithology	Thickness (in feet)
Quaternary		Alluvium and river gravels	
Tertiary	Mangalore	Clay and sand	5 +
	Brighton Basalt	Olivine basalt flow	150 +
		Plug of olivine basalt	
Early Tertiary (?)	**Strong Faulting**		
Jurassic (?)		Tholeiitic dolerite sills and dykes	
Triassic	Knocklofty Sandstone and Shale	Sandstones and shales	1000 +
Permian	Ferntree Mudstone	Mudstone	200 +
	Risdon Sandstone	Sandstone	20
	"Woodbridge Glacial Formation"	Siltstones and fine sandstones	250

IGNEOUS ROCKS

Jurassic (?) dolerite was intruded as rather irregular sheet-like and dyke-like bodies. Almost invariably the sedimentary roof rocks of the intrusions have been removed by erosion along with some of the dolerite, so that the maximum thickness remaining in a sill-like body is about 800 feet. The complex outcrop pattern of dolerite and sediment in the north-eastern part of the area is possibly due to the interfingering of two sheets of dolerite originating from different centres of irruption.

The Brighton Basalt of Tertiary age has flowed down the pre-existing Jordan valley, flooding back up the valleys of the Bagdad and Strathallern Rivulets. Only one flow is present which in the south exceeds 150 feet in thickness. The basalt is a massive to vesicular and amygdaloidal, olivine-bearing type normatively saturated in silica. Depending on the position within the flow the texture varies from porphyritic with a glassy groundmass to typically ophitic. Polygonal joint columns are usually developed and in some cases groups of such columns present most extraordinary forms, varying from fan-shaped groups to "synclines" up to 120 yards across.

A plug of olivine basalt, probably also of Tertiary age, occurs north-west of Maiden Early.

POINTS OF SPECIAL INTEREST

"Syncline" of basalt columns (5115E 7400N).
Fan shaped group of basalt columns (5135E 7438N).
Section through basalt flow showing the strong textural variation (5142E 7438N).
Intrusive contact of dolerite with sandstone (5139E 7438N).
Triassic sandstones showing current bedding (5187E 7439N) and slump structures (5133E 7446N).

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THE UNDERGROUND PHASE OF VOLCANIC ACTIVITY

By

Frederick Walker

University of St. Andrews, at Dundee

The R. M. Johnstone Memorial Lecture
August, 1957

ABSTRACT

A survey is made of the hypabyssal activity associated with kratogenic outpourings of plateau basalt. It is shown that sheet and sill injection have volumes of the same order as that of the lava phase and far greater than that of the dyke phase. The form of lateral injection and its position in the time sequence of vulcanicity are discussed and also the possibility of hydrostatic control acting as a governing factor. Consideration is given to the quantitative aspect of contact phenomena, in particular of metasomatism. The relationship between the olivine basalt and tholeiitic magma-types is touched on briefly.

INTRODUCTION

Igneous activity is probably the most important of all natural phenomena. Not only is it fundamental in the evolution of the earth's crust, but its surface manifestation, volcanic extrusion is both spectacular and terrifying. Yet volcanic outbursts are accompanied by underground phenomena of even vaster scope. These cannot be seen in action, but erosion, working through millions of years, has laid bare their secrets and has shown them to provide important clues to that most difficult problem, the diversification of igneous rocks. In what follows I will attempt to summarise some of the evidence to be found on this question in the less deep-seated of igneous injections.

GRANITE AND BASALT

It is many years since Daly called attention to the dominance of basalt amongst volcanic rocks and of granite amongst deep-seated intrusions. If these two rock names are used in their broadest sense to include pyroxene andesite, oceanite and limburgite in the first case and granodiorite in the second, their position is even more outstanding. But, as Kennedy has emphasised (in Kennedy and Anderson, 1938, pp. 27-33), there are profound differences other than that of chemical composition between these fundamental rock-types. Basalt with its underground equivalents dolerite, gabbro and norite, is of volcanic association connected with extrusive outbursts during which basic magma made its way swiftly to the surface. Granite, by contrast, is of plutonic habit. It too may have its surface equivalents but these are rare and insignificant. The vast majority of granite batholiths had no surface connection, being formed at depths measurable in miles rather than feet. Granite formation seems to have been a slow process, even by geological standards, involving wide-spread soaking and impregnation with metasomatic transfer of enormous quantities of material. Only the relatively scarce granites of volcanic association show the clear-cut margins and chilling phenomena characteristic of the basalt clan.

It is this basalt clan that concerns us here. The granitic phase of crustal injection is still too problematical for accurate assessment and in any case has been fully discussed in recent years, notably by Read (1957). Basaltic rocks, on the other hand, have may properties which are measurable quantitatively and throw light on the problems of differentiation.

Dolerites as Subjects for Study

Recent work on the basalt clan may be grouped under three headings:—

(1) Optical and chemical surveys of deep-seated and highly-differentiated intrusions such as the Skaergaard, Stillwater and Bushveld. In spite of their great size, these belong to the volcanic associations of Kennedy.

(2) Attemps to arrive at general principles by collation of chemical and optical data.

(3) Studies of the differentiation of individual hypabyssal intrusions or of lava series.

I will now attempt to show why investigation of hypabyssal intrusions, especially of flat-lying sheets and sills is of particular importance, and to make a broad quantitative survey of this type of igneous activity. My reasons for concentrating on flat-lying intrusions are these:—

(*a*) Their aggregate volume greatly exceeds that of dykes.

(*b*) The majority have been emplaced by a single impulse and even in cases of composite or multiple intrusion, the sequence is relatively simple. This is in marked contrast to the great layered intrusions of lower levels where the problems of differentiation are complicated by strong convection.

(*c*) All flat-lying bodies possess a definite floor and roof against which constituents rising or settling during the cooling process tend to accumulate . In basalt lavas roof foundering and turbulent flow over uneven surfaces may render investigation more difficult. Differentiated dykes may also possess roof and floor but such cases are rare and often poorly exposed.

(*d*) The limited thickness of differentiated sheets and sills makes for rapid investigation. In many cases exposures are excellent and in a few complete bore-cores are available. In lavas these advantages are off-set by marginal vesiculation and decomposition.

(*e*) Most sheets or sills have well-marked chilled margins which yield accurate information as to the composition of the magma at the time of emplacement. These are generally lacking in lavas.

(*f*) Rheomorphic, anatectic and metasomatic phenomena, as well as assimilation, are on a more limited scale than in plutonic masses which leads to relatively easy detection and investigation.

(*g*) Hypabyssal intrusions show a transition between plutonic and volcanic conditions and are therefore useful in indicating the limits of stability of the constituent mineral series under varying physical conditions. This applies with special force to the pyroxenes and plagioclase felspars.

It will thus be seen that the investigation of flat-lying dolerite intrusions is likely to be particularly rewarding and that the facilities they afford are shared by dykes to a much lesser degree and still less by lavas. Let us see now how these sheets and sills bulk in the earth's crust, whether greater or less than basaltic lavas, and how they compare with the great layered intrusions. In this survey the primary and parental nature of basic magma is a vital premise.

Volume Comparison between Basalt and Dolerite

Basic rock in the form of basalt or dolerite is dominant in all the great lava plateaus of the world and in their associated hypabyssal intrusives. It seems, indeed, that the rapid ascent of molten sima during periods of crustal tension is the distinguishing characteristic of this type of vulcanicity. But when one attempts to estimate the relative bulk of the extrusive and hypabyssal phases difficulties are at once encountered.

In the case of the lavas there can be no evidence, except in recent outbursts, of the proportion removed by erosion. An extreme example is seen in Tasmania where the post-Triassic dolerites have no equivalent extrusive phase exposed. We cannot here be sure as to whether any lavas of this age actually existed. Only in lava series interbedded with sediments can there be any certainty as to the original thickness.

Another difficulty is in tracing the lateral extent of eroded basalt plateaus. Since basalt breaks down quickly during transport it is unlikely to be found in conglomerates. Some cases, however, may reveal slumped masses of basalt lavas which have now been completely stripped from the surface. An excellent example of this is found in Arran (Tyrrell, 1928, 181), and another still more striking in the Karroo near Prieska (du Toit, 1954, 417). In the latter case the presence of slumped Stormberg lavas in kimberlite pipes demonstrates that the basaltic flows of the Basutoland plateau extended westward for at least 300 miles beyond their margin today.

The difficulty of estimating the bulk of magma in a hypabyssal assemblage is also formidable. The volume of the dyke phase is relatively small and we may, in the meantime, confine our attention to the more concordant and flat-lying intrusions. There seems to be a definite tendency for basic magma to spread laterally at well-marked geological horizons, possibly through hydrostatic control, and there are seldom more than three or four levels of such spread. This is well seen along The Great Escarpment of South Africa—in particular in the deep valleys of the Transkei. The same is doubtless true of the Tasmanian dolerites but dense bush tends to mark the lower outcrops. Exposures are also poor in the Palisadan province but here as in Tasmania, drilling has yielded compensating information.

In the Karroo and Palisadan provinces the extrusive and intrusive phases seem to have volumes of the same order. In the focal region of the Karroo activity the total thickness of the lavas probably exceeded that of the sills, but in outlying areas the aggregate thickness of sills and sheets was probably the greater amounting to over 3,000 feet in the Stormberg and Kokstad districts. In the Palisadan province the total thickness of the lavas reaches a maximum of 900 feet against at least 2,000 feet for the flat-lying intrusions. In addition, there can be little doubt that the sills and sheets had the greater lateral extent.

The sill phase of the Lower Carboniferous activity of Central Scotland is probably less in volume than the plateau lavas but again the bulk of both is of the same order. One of the chief difficulties in making these estimates is in the determination of the lateral extent of the sills and sheets, but the general indication is that in a given terrain the flat-lying intrusions thin out more gradually and extend further than the equivalent lava series. It is at any rate clear that the volume of hypabyssal basic rock accompanying the great plateal eruptions is in no way dwarfed by them and in some cases is actually greater.

The Relationship of Deep-seated, Layered Complexes to Dolerite and Basalt

The layered lopoliths and kindred intrusions of more deep-seated habit are sometimes of such dimensions as to approach an entire sill suite or lava plateau in bulk. Thus the Bushveld Igneous Complex of the Transvaal with a probable volume of over 250,000 cubic miles greatly exceeds that of the associated suite of diabase sills or the volcanic series which were its harbingers. This, however, is an extreme case and the lavas and minor intrusions of the Bushveld are not comparable in bulk to the Stormberg volcanics or the associated Karroo dolerites.

Other lopolithic masses of similar dimensions are known, e.g., that of Duluth, but they are not common and it is doubtful whether their world volume approaches that of the great lava plateaus with their associated minor intrusions. It may, nevertheless, be noted that the hypabyssal bodies sometimes contain numerous xenoliths of peridotite and other rocks formed under deep-seated conditions so that the presence underground of major plutonic intrusions may be inferred even if they are not exposed. Such phenomena are frequent in the hypabyssal intrusions associated with the Carboniferous volcanics of Central Scotland.

The Volume of Dyke Swarms

Lastly there are the associated dyke swarms to be considered. Each major lava plateau has its dykes which may form the actual feeders of the flows, but sometimes represent a later and final ascent of magma under conditions of crustal tension. The dyke swarms bulk in general far less than the lavas and flat-lying intrusions. In the Karroo, Palisadan and Tasmanian provinces (Trias-Jura) and the Central Valley province of Scotland (Carboniferous) this is quite obvious from the examination of the relevant geological maps. The British Tertiary province, however, provides a case where not only is dyke intrusion much more abundant but where quantitative data are available. The most spectacular development of dykes is at the margins of the great plutonic centres, notably Mull and Arran, where admirably exposed shore-sections are available. Here the dyke swarms have aggregate thicknesses of 2,504 and 6,050 feet respectively, figures which match those of even the greatest lava plateaus or their sill suites. But the height and length of a dyke are by no means comparable with the equivalent measurements of an important sill, that is the lateral spread which may cover over 4,000 square miles. Furthermore, the dyke swarms of Mull and Arran fall off rapidly in thickness away from the plutonic foci (Richey, 1939, 424).

There remain the cone-sheet systems of the British Tertiary ring structures. No details of their aggregate thickness are available but around the plutonic centres of Mull and Ardnamurchan, where they find their strongest development, it must amount to several thousand feet. Their vertical and lateral extent is, however, strictly limited so that their volume will be much less than that of a dyke-swarm.

The main conclusion to be drawn from this brief survey is that the sill phase matches in bulk, if no more, the extrusive and the lopolithic and may well exceed them as dyke swarms and cone-sheet systems have aggregate volumes of a distinctly low order.

The Origin and Relationship of the Sill and Lava Phases

Neglecting for the moment dyke swarms and deep-seated layered intrusions, we may now examine the structural relationships of the sill and lava phases of flood-basalt episodes. It is of particular importance to determine the sequence of activity and how this may be modified by the structure of the invaded rocks.

Whatever local variations in structure there may have been during these eruptions it is at least certain that they are all associated with periods of marked crustal tension. Only this could permit the rapid ascent through fissures of vast volumes of basaltic magma derived from reservoirs (presumably stratiform) of fused sima. Where the rocks underlying the great lava plateaus have been trenched deeply by erosion the habit of the flat-lying intrusions is seen to be controlled by the structure of the rocks traversed, though the detailed mechanism and the sequence of events remain uncertain. Consideration of a few carefully studied provinces of which I have personal knowledge will illustrate this.

Karroo Dolerites and Stormberg Lavas.

In the Karroo province of South Africa the ascent of basic magma through the Basement Complex was by narrow dyke fissures. These continued upwards into the flat-lying sediments of the Karroo System in which the magma developed a tendency to spread laterally. At low horizons in the System the spread was largely concordant but at higher levels cross-cutting sheets are found which become less common in the Stormberg Series and absent from the lavas themselves. The concordant intrusions tend to follow bedding planes between siltstone and pelitic layers, especially above the massive well-jointed siltstones which are prominent in the Beaufort Series.

The cross-cutting sheets have been termed "conical sheets" by Lombaard (1953, 181-186) and compared to true cone-sheets. They are considered by him to have stemmed from convex irregularities or cupolas on the roofs of concordant sills. From these they made their way upwards until in the Stormberg Series they developed sufficient gas pressure to break through to the surface and form numerous ash vents of central type, sometimes invaded by dolerite or basalt. These vents are abundant in the Cave Sandstone north of 29° 30′ and their relationship to the conical sheets is complementary. Freezing of the magma from above downwards then sealed off the early channels and it was left to a set of younger dykes to ascend and pour out at the surface as the Stromberg Lavas. There is little doubt that these volcanics arose from fissure eruptions, for the dyke feeders are seen to penetrate to high levels in the lava plateau. Lombaard appears to envisage the following sequence of events:—

(1) Ascent of early dyke-suite into Karroo System.
(2) Lateral spread of concordant sills in lower part of System.
(3) Ascent of conical sheets from cupolas on roofs of sills.
(4) Increasing gas pressure at higher levels causes conical sheets to break through to surface and form ash-lava vents of central type.
(5) Freezing of magma from vents downwards seals off further ascent of magma.
(6) Renewed tension gives rise to later dyke swarms which reach surface and build up lava plateau.

Du Toit, on the other hand (1954, 567-568) proposed a different sequence:—

(*a*) Breaking through of diatremes and ash-lava vents of central type in Cave Sandstone time.

(*b*) Fissure eruptions build up lava plateau.

(*c*) Impenetrability of thick lava cake leads to lateral spread of magma underground to form sill and sheet phase.

(*d*) Renewed tension results in main dyke phase which penetrates lavas.

Scholtz (1937, 202, 203) agrees with du Toit in considering that early extrusion produced an impenetrable lava cake causing the magma to spread laterally in the underlying sediments.

Here, then, in a province with fully developed and admirably exposed extrusive and hypabyssal phases opinions differ as to the sequence of events. We may notice, however, that Lombaard's conception of conical sheets differs from the type examples by comprising a single cone-shaped injection instead of a concentric series with increasing dip towards the centre.

The Dolerite Dykes of the Cape Peninsula.

In the Cape Peninsula and its immediate vicinity there is developed a series of tholeiitic dykes which are probably of Karroo age since they cut Siluro-Devonian strata of the Table Mountain Series. The behaviour of the magma is different here. It penetrates the Precambrian granite and associated metamorphic rocks by means of short narrow dyke fissures. These traverse the basal shales and flagstones of the Table Mountain Series but end abruptly without any tendency to spread laterally when the first massive quartzite is reached. The Table Mountain sediments, though lying relatively undisturbed between two tighly folded orogenic zones of the Cape Foldings, are nevertheless closely cemented and brittle with widely spaced joints so that magma would find no easily followed horizontals channels as in the Karroo sediments.

Palisadan Dolerites and Lavas.

The basic rocks of the Palisadan province are less perfectly exposed than those of the Karroo but have been studied as fully. Yet they provide no further clues as to the sequence of eruption. Recent work by Hotz (1952) on the Pennsylvanian sheets, aided by extensive drilling, has, however, thrown light on the form of the sheets. Few of them are strictly concordant, the majority having a marked inward dip producing annular outcrops very similar to those of the conical sheets in the Karroo. Drilling has shown that they have a platter-like shape with horizontal floors and one therefore wonders whether the Karroo sheets may not also have this form. It must be noted, however, that unlike those of the Karroo, the Palisadan sheets were injected into Triassic strata which had been already gently flexed and faulted, and that though the inclined sides of the body may be conformable, the horizontal floors are transgressive. Furthermore, the extrusives of the province were relatively unimportant. The magma traversed pre-Triassic formations by means of dyke fissures.

Hotz makes a comparison with the Karroo sheets but comes to no definite conclusions as to the mode of origin or the position in the eruptive sequence of the Pennsylvanian sheets.

Tasmanian Dolerites.

In the Tasmanian province which is penecontemporaneous with the Palisadan and the Karroo, the volcanic phase is entirely absent from present exposures and may never have existed. As in the Karroo, the Permo-Triassic sediments are largely undisturbed and flat-lying. In the following brief account I have been aided by stimulating discussion with Professor S. W. Carey and Mr. A. Spry. The latter has added to my indebtedness by providing a written summary of his views, which I quote below:—

> "Sedimentation (total of about 4-5,000 feet of Permo-Triassic) on a folded basement continued up to the time of intrusion. The magma must have risen through major fractures in the basement but then reached materials which were quite different in their physical properties. This is similar to the examples of the Cape dykes where intrusion passes up through granite then ceases in overlying sediments. It seems that crustal tension caused fractures in the brittle granite but is relieved by interangular movement or jointing in the overlying sediments. In Tasmania I think that the dolerite magma rose through quite large openings in the basement (dykes, ring-dykes or cone-sheets), but when it reached the base of the sediments it met materials which were soft, semi-consolidated and *lighter* than itself. The magma found it easier to intrude along the strong bedding planes and to lift its light roof than to burst through to the surface because major vertical fractures would be sparse. One might expect a thickening of the body near the source to give a laccolithic habit but this does not seem to be so here. It looks more like the synchronous intrusion of magma from a whole series of sources with the coalescing of the magma to give a very large sheet which runs horizontally and steps up and down. If liberation of the magma had continued then one might have expected surface volcanism to follow intrusion because the sediments would have been rendered brittle by the abundant dolerite.
>
> "It seems to depend on local conditions which happens first because the magma will travel along the easiest path. It is likely that if the magma is liberated at the surface by a vent and then becomes solid later, magma will be encouraged to move sideways and form intrusions. One must evaluate the relative importance of the strong pressure gradient tending to burst the magma through to the surface against the bedding plane and joint weaknesses tending to encourage intrusion. The relative densities of the magma and the country rocks are, of course, very important as will also be the regional tectonics of the area."

In Tasmania Professor Carey and Mr. Spry take the view that lateral spread in partly-consolidated sediments proved easier than a break through

to the surface and that extrusion, if it ever took place, came after the phase of sill injection. Mr. Spry's contention that sill injection renders the sediments more brittle will be discussed at a later stage.

Permo-Carboniferous Province of Central Scotland.

Having now dealt with three tholeiitic provinces, we now turn our attention to one which is dominantly alkaline olivine basalt. Though small, it has been mapped in greater detail and more carefully studied than any other. The associated sediments range through the whole of the Carboniferous System into the Lower Permian and are flexed and faulted without any trace of metamorphism. A very complete and thoroughly documented account of the eruptive sequence in time and place has been given by MacGregor (1948).

In this province, sill injection and extrusion of alkaline olivine basalt magma are of equal importance. Dyke injection is localised and of quite minor character except for a strongly developed system of E.-W. tholeiitic dykes which came as an unheralded interruption at the close of the Carboniferous. MacGregor, following Kennedy and Anderson (1938), attempts to account for the variation in the eruptive types by an hypothesis of crustal layering with fusion at different levels at different periods. Other mechanisms have been proposed by Daly (1933, 391-392) and by Tomkeieff (1937).

In the eastern portion of the Midland Valley there is definite evidence that extrusion of lavas preceded sill injection. The volcanics occur in the Calciferous Sandstone Series down to the very base but are not found in the succeeding Carboniferous Limestone Series. On the other hand, the sills, besides spreading at all levels in the Calciferous Sandstone Series, occur abundantly in the Carboniferous Limestone Series, though conspicuously absent from the Millstone Grit and Coal Measures of the Midlothian and East Fife coal basins. There is evidence that some of them are of Calciferous Sandstone age, for examples in that series have their upper contacts veined with unconsolidated sediments of that facies. The Armorican stress system prevailed throughout this period and the sills are concordant with step-like transgressions as in Tasmania.

Both extrusive and intrusive activity persisted longer in the west, but before the close of the Carboniferous the magma channels became sealed off. The next episode was the injection under the succeeding Borcovician stress system (Anderson, 1951, p. 43) of a great series of tholeiitic dykes and sills. These were followed by a recurrence of alkaline olivine basalt lavas and intrusions in early Permian time, the relationship between extrusive and intrusive bodies being similar to that prevailaing in the Lower Carboniferous though with certain modifications, e.g., a Permian agglomerate vent is visibly connected with a 30-feet monchiquite dyke in Ayrshire.

We may now apply Mr. Spry's suggestion that sill injection by hardening the invaded sediments and rendering them more brittle modified the nature of subsequent eruptive episodes. This does not appear to have been the case in the Midland Valley. The great alkali dolerite sill system of the Carboniferous and the later quartz dolerite dykes and sills have not been able to alter the contact sediments significantly or to alter the eruptive time sequence in subsequent Permian outbursts. These resemble in all major points the Lower Carboniferous activity and there is good evidence that in this province that the magma broke through to the surface without spreading laterally in the contact sediments consisting largely of interbedded sandstone and shale which would have provided easy passages for conformable injection. Conditions of crustal tension must have prevailed for this to happen and the paucity of dykes is rather surprising. It is clear, however, that both lava and sill phases were fed through mapor orifices and not narrow dyke fissures.

Scottish Tertiary Province.

The Scottish portion of the vast Brito-Icelandic province has received the same large-scale mapping and detailed study, but the associated sediments are flat-lying as in the Karroo and Tasmania and the vulcanicity is characterised by a spectacular development of ring-structure (Richey, 1932). Another feature of the province is the appearance at an early stage of both tholeiitic and olivine basalt lavas.

The evidence in Skye favours the view that lavas fed through dyke fissures preceded the main phase of sill injection (the Great Sill Group), the plutonic rocks of the Coolin centre intervening. These sills consist of alkaline olivine dolerite with picritic differentiates and are considered by Harker (1904, Chapter XIV) to occur abundantly in the plateau lavas as well as in the underlying sediments. Later work by Kennedy (1931, 166) and others has shown that in some cases they are the compact centres of lava flows but there is no doubt that sills belonging to the Great Group do occur in the plateau lavas. The majority of these sills, however, are intruded into the underlying Mesozoic formations in which their aggregate volume is very great. They are extremely concordant, on the whole, but may show step-like transgressions.

The focus of the Great Sill Group must lie to the north of Skye for the sills increase in aggregate thickness in that direction. There is not the same development of sills in other Tertiary centres except in South Arran where four thick crinanite sills are injected into the New Red Sandstone. They are themselves cut by later dyke swarms related to the plutonic centres, but there are no lavas to date them more precisely.

General Observations

Of the five provinces discussed above, two show definite evidence that lavas preceded sill injection (Scottish Carbo-Permian and Tertiary). Two leave the matter in doubt (Karroo and Palisadan), while the remaining Tasmanian province has no visible extrusive phase (due, in the opinion of local geologists, to a tendency to spread laterally along bedding planes rather than to wedge through to the surface). All five provinces are in kratogenic regions where the eruptive episodes occurred under conditions of marked crustal tension, but, whereas dyke intrusion is conspicuous in the Scottish Ter-

tiary and Karroo and moderate in the Palisidan province, it is relatively scarce in the Scottish Carbo-Permian and Tasmanian provinces where the magma was afforded upward passage through major orifices such is pipes and elongated bosses.

Amid this conflicting evidence it seems clear that the sill phase which we are now considering is developed regardless of the form of the vertical feeders. Furthermore, in the two most closely studied provinces where large scale mapping (6 inches = 1 mile) has been carried out, the sill phase succeeds the lavas which broke through to the surface without lateral spread.

Mr. Spry suggests that magma may find it easier to lift its roof and spread conformably in partly consolidated sediments than to wedge its way to the surface, but neither in Tasmania nor in the Karroo has convincing evidence been advanced. His further suggestion that the sediments may be rendered brittle by dolerite invasion, and so provide easier vertical passage for lava feeders, seems very doubtful. Even thick sills only affect the contact sediments for a few feet and the invaded strata as a whole suffer no significant modification.

On the other hand, the power of massive formations with widely spaced joints and little pore-space to halt the ascent of magma, is unquestionable in the case of the Cape Peninsula dykes which terminate below the first massive quartzite encountered. To sum up, it seems that rapid and direct ascent of basic magma to the surface initiates igneous activity in at least same kratogenic regions and that the sill phase followed, either as a result of hydrostatic control or the mechanical impenetrability of a thick cake of lava. No positive evidence is available that magma found it easier to spread conformably by lifting its roof than to break through to the surface, though such a process is clearly conceivable. The main horizon of sill injection may be quite restricted, which would indicate some form of hydrostatic control or may have an extended vertical range as in the Scottish Carboniferous.

Diversification of Dykes and Flat-lying Intrusions

In distinguishing between volcanic and plutonic associations, Kennedy (in Kennedy and Anderson, 1938, 30-31), in common with other petrologists, has emphasised the importance of crystallisation differentiation in the former. This finds confirmation in every kratogenic province, but it will be seen that the differentiation trend in dykes differs from that in flat-lying intrusions. Dealing with the Tasmanian dolerites, Edwards (1942) has adduced ample petrological and chemical evidence to show that broad dykes may be regarded as open chambers, whereas flat-lying intrusions are closed.

Crystallisation Differentiation in Dykes.

The narrow dykes of great swarms are characteristically free from differentiation phenomena in place. Composite and multiple dykes are abundant, but each member thereof tends to be uniform in itself.

The case is very different in broad dykes or elongated bosses, the central portions of which were slowly cooled. Here the early formed mafic minerals (magnesian pyroxenes and olivine) tend to settle by gravity, once ascent of magma has ceased, to lower levels at which they are lost to observation. The result is a transition from chilled margins representing the composition of the magma at the time of emplacement to a centre impoverished in dark minerals. Gunning's Sugar Loaf (Edwards, 1942, 474-477) provides an almost perfect example of this process. The margins have compositions showing excellent agreement with the average for undifferentiated Tasmanian dolerite but a traverse to the centre exhibits a gradational change to felspar-rich pyroxene-poor varieties. The centre has the composition of an alkali-poor andesite very different from the iron-rich differentiates found in the upper portions of intrusions with roof and floor.

Such a mode of differentiation can only take place in really broad dykes or elongated bosses with parallel walls. If the dyke is floored at levels exposed by erosion, as in the case of Elephant's Head in South Africal (Poldevaart, 1944), the settling minerals will accumulate on the floor to form ultramafic types such as picrite or pyroxenite. The same result might, however, be brought about by a constriction in the passage and this is possibly the case in the Glen More ring dyke of Mull (Bailey and Thomas, 1924, Koomans and Kuenen, 1938). Even narrow dykes may show the results of differentiation, though not in place. Bowen (1928, 149-159) has described how the peridotite dykes of the Coolins in Skye have margins of olivine basalt representing the original magma which warmed up the passage and permitted the ultramafic accumulate to ascend. These, however, are in the nature of composite dykes, though the internal contacts may be transitional.

Differentiation of Flat-lying Intrusions with Roof and Floor.

The differentiation of sheets is in every way more diverse and important than that of open dyke chambers. There are two main reasons for this: first, because the roof and floor limit the rising and settling of crystals in the intrusion so that crystal accumulations become clearly visible in eroded examples; second, because the average thickness of a sheet tends to be greater than the average breadth of a dyke so that cooling is slower in sheets and gravitational differentiation more likely to occur, the more so because sill magma after injection is static, whereas a feeder dyke may be an open channel liable to many subsequent pulsations. Furthermore, as I have already emphasised, differentiated sheets may exhibit interesting transitional phenomena. In addition to the features of sills set forth earlier, the following may be noted:—

(*a*) By study of sills and sheets the critical dimensions at which significant crystallisation differentiation takes place may be determined and will be found to differ markedly in tholeiitic and olivine basalt provinces. Quite strong differentiation in place may occur in olivine dolerite sheets (in particular, teschenitic examples) under 100 feet thick, whereas a differentiated sheet of quartz dolerite or tholeiite is very rare.

(*b*) In tholeiitic sheets inversion from pigeonite to orthopyroxene is common and provides accurate estimates of the temperature of intrusion, e.g., slightly over 1100° C. in the Palisadan and Karroo provinces (Hess, 1956, 446).

(*c*) Many tholeiitic sills contain orthopyroxene in their lower portions at higher levels richer in volatiles. An indication is thereby given of pyroxene crystallisation under dry and wet conditions.

(*d*) Most dolerite sills have well-defined chilled contacts in which phenocrysts indicate the nature of the pre-injection crystallates and outline the early cooling history of the magma. Other contacts, however, are gradational and show interesting transfusion phenomena, but this applies with equal force to dykes.

(*e*) The intrusion temperature of dolerite and its volatile content are marginal in so far as palingenesis, rheomorphism and metasomatism of contact sediments are concerned.

Mechanism of Crystallisation Differentiation.

Gravitational settling of the early crystallates seems to be the main process of crystallisation differentiation. All of them are denser than the magma in which they crystallise and may settle either as discrete crystals or as aggregates of more than one mineral, e.g., pyroxene and calcic plagioclase (Jaeger and Joplin, 1955). They will then accumulate on the upward-growing floor of the intrusion, forming rock types rich in pyroxene or olivine. Plagioclase being only slightly denser than the magma, shows much less tendency to settle.

Olivine may settle from either tholeiitic or olivine dolerites to produce picrite dolerite or picrite, but significant sinking of pyroxene is found not only intholeiitic sheets such as the Palisades (Walker. 1940) and Mount Wellington (Edwards, 1942, 466-471). In olivine dolerite magma pyroxene is of relatively later crystallisation than either olivine or plagioclase and does not accumulate by gravity (Walker, 1957).

Hess (1956) has argued that the differentiation of the Palisades and other tholeiitic sheets showing a downward increase in pyroxene, may be the result of normal crystallisation plus convectional circulation without sorting, but some of his data are not confirmed by the observations of other workers (in particular, the relative tihckness of the upper and lower chilled phases).

One feature of differentiated sills which has not received enough attention is the complications introduced by the later injections of undifferentiated magma which I have termed "cognate". They are very common, but, being difficult to detect in the field, have escaped notice (Walker. 1957a, 90). Even the type examples of the Palisades and Shiant Isles are not free from them and I have found them in every dolerite province in which I have carried out detailed work. They are still more common and considerably easier to detect in dykes, e.g., those of the Cape Peninsula (Walker, 1957a, 78-80). Internal contacts are always sharp but may or may not be chilled. Apparently the magma, having once opened up in a channel, is followed by subsequent impulses without difficulty, sometimes along the join system, but more often taking independent courses. They are generally of insignificant volume compared with the original injection and differ therein from true multiple intrusions which seem to be confined to the vicinity of the plutonic centres associated with flood basalts.

Residual injections in sills (and dykes) are again insignificant in bulk, but are of the greatest interest as indicators of the differentiation trend. They occur as veins, schlieren or irregular patches either conformable to the contact or cross-cutting . Those in olivine dolerite intrusions grade through alkaline dolerite pegmatite into syenitic modifications with abundant analcite and nephaline, whereas in tholeiitic bodies the variation is through quartzose dolerite pegmatite into granophyric and felsitic types, the final stage being a quartz-albite rock. The mechanism of segregation and injection is not clear, but some of the latest veins seem to be hydrothermal replacement products rather than orthomagmatic.

Palingenesis, Rheomorphism and Metasomatism of Contact Sediments

Though the intrusion temperature of dolerite is generally in the neighbourhood of 1,100° C. and the initial fusion temperature of shale, arkose or siltstone (which are the most common contact sediments) some 400° C. lower, there is very little melting or mobilisation of the country rock in most dolerite suites. According to Jaeger's calculations, a temperature of over 630° C. cannot be reached in the contacts of a dolerite sill (1957, 310), but the field evidence is against this. In cases where the contact rock is fused more or less completely, tridymite is found fringing residual quartz grains. The inversion point between tridymite and high-temperature quartz is 867° C. and the change is sluggish so that a much higher temperature than 630° C. seems indicated. Tridymite is also found in unfused contact hornfelses. Let us now consider the phenomena observed.

Palingensis, or pure melting of contact sediments by dolerite is not a common phenomenon, though it has been recorded from several provinces. In no case is fusion more than local and it is confined to the immediate contact or to sedimentary xenoliths. The fused material seems always to be of quartzo-felspathic composition with quartz generally in excess of eutectic proportions. Excess Al_2O_3 goes to make cordierite. Glass disappears a few feet from the contact and fully-vitrified specimens have the appearance and chemical composition of pitchstone.

Rheomorphism is a much more common phenomenon than palingenesis and in certain provinces such as the Karroo it may be seen at the majority of well-exposed contacts. The mobilised sediment may be quartzo-felspathic, pelitic or semi-pelitic and, though a certain amount of transfusion and syntexis may take place, the sedimentary veins in the igneous rock resemble closely the baked sediments from which they have come. There may, however, be a tendency towards flueion structure. Though the evidence in favour of mobilisation is

clear and convincing, the mechanism by which it was brought about is not yet clear. No glass occurs and the development of the liquid phase necessary to produce flow must have been quite slight in view of the resemblance between veins and contact sediment. Occasionally mobilisation is accompanied by marked transfusion with the production of gradational contacts (Walker and Poldervaart, 1943, 63; Drever and Johnston, 1957). Even in the best developed cases the volume of the material mobilised is minute compared with that of the igneous rock so that the temperature necessary to produce mobilisation cannot have been greatly exceeded.

Some dolerite provinces appear to be magmatically dead but recent work on well-exposed contacts has shown that the mobilisation temperature has just been reached in the Whin Sill and Palisadan provinces (Walker, 1958).

Metasomation of contact sediments and xenoliths is in every way a much more important process capable of converting, under suitable conditions, very considerable volumes of sedimentary material into rocks of definitely igneous aspect. Metasomatised sediments are particularly prominent in the Karroo province, especially in the roofs and partings of sills, and were described by Rogers and du Toit (1909) as dioritic and granophyric modifications of dolerite. Both the fabric and mineralogy of these rocks might well be taken as igneous either in the field or in thin section, but detailed examination reveals sedimentary structures and associations. Thus partings show residual kernels of unaltered sediment and granophyre which may be traced laterally into siltstone along blocks which have become partially detached from the upper contact (Walker and Poldervaart, 1942; 1949, 674-684).

The metasomatic process involves transfusion of caferric oxides into the sediment and of silica into the dolerite. The sediments affected are almost invariably siltstone and are enriched in iron, soda or potash, according to the magmatic stage reached at the time. A marked feature of these metasomatised siltstones is the development of elongated prisms of pyroxene nearly always serpentinised.

Metasomatism may be accompanied by mobilisation and rheomorphic veining of the igneous rock but in other cases delicate sedimentary structures such as small clay pellets are perfectly preserved.

Probably the most important feature of metasomatism is its quantitative aspect. This is well illustrated by the dolerite sill of Rietkop in the Karroo, which has almost completely metasomatised into granophyre a 70-feet parting of siltstone leaving unaffected only a few residual kernels of baked sediment. *Thus a dolerite sill in certain circumstances may transform one third of its own bulk of typical sedimentary material into rock of definitely igneous appearance and chemical composition.*

One may well ask what happens at depth and consider the case of the great "gap dykes" of the Transkei which Mountain (1944) considers to be of metasomatic origin at lower levels. If such widespread phenomena are produced by relatively small stratiform masses, what will be the fate of a tectogene immersed in sima? Even in dolerite provinces where there is an apparent absence of rheomorphic and metasomatic phenomena, the critical physico-chemical conditions for their initiation, are as mentioned above, closely approached.

Depth of Lateral Injection

It has frequently been suggested that the depth of sheet and sill injection may be governed by hydrostatic control, but we have seen already that the evidence is by no means clear. Every stratigrapher is familiar with the difficulty of drawing satisfactory isopachs and in the case of lateral hypabyssal injection there is the additional complication of placing flat-lying intrusions correctly in the eruptive time sequence. Vesticulation of margins may help and once more the Karroo province provides an instructive example. Lombaard (1953, 176), observed that dolerite dykes below the Cave sandstone (the highest sedimentary division of the Karroo System) are unvesiculated, whereas those in the sandstone have vesicular margins. He draws the logical conclusion that the latter were injected under a light load. Assuming that the overlying Stormberg lava plateau was in existence when the dykes were emplaced, we may arrive at a very approximate estimate of 5,000 feet as the depth of cover necessary to inhibit marginal vesiculation. This figure is obtained by adding the thickness of the Cave Sandstone to that of the lava pile in the area of Lombaard's investigations. Although tentative, this figure is in keeping with observations made in other provinces such as the Scottish Carboniferous and the Palisadan. Unfortunately, I have no data covering the Great Sill Group of Skye, which seems the most promising field for further investigation. If the critical depth for the inhibition of vesiculation can be established and shown to be reasonably constant in spite of the variables involved, it will be a very useful yardstick for the study of hydrostatic control as the governing factor in sheet injection.

Tholeiitic and Olivine Basaltic Provinces

I cannot leave this brief and somewhat disordered survey of hypabyssal vulcanism without some reference to the relationship between the two fundamental magma-types of kratogenic outbursts, the tholeiitic or normatively saturated basalts and the unsaturated olivine basalts. Until a few years ago opinion seemed to be trending towards the idea that the tholeiitic basalts and dolerites were invariably associated with the sialic continental blocks and were absent from oceanic islands beyond the folded arcs. The name "sub-sialic" was proposed for them (Wells and Wells 1948) and their origin through sialic contamination of sima was thought likely. Kennedy and Anderson (1938) advanced an hypothesis of crustal layering by which magma reservoirs of great lateral extent were formed by the fusion at appropriate depths of layers of different composition in a down-warped section of the crust. Thus tholeiite magma might be generated at the top of the "upper intermediate layer" while olivine basalt magma would be formed at the top of the "lower intermediate layer". In the foreland and hinterland areas fusion would be confined to the olivine basalt layer. Anderson con-

siders the " lower intermediate layer " to be graded with increase of density downwards.

MacGregor (1948, 144-145), applying this hypothesis to the Scottish Carbo-Permian province, went a step further and, accepting Anderson's concept of grading, considers it probable that fusion took place at different levels at different times and never simultaneously as postulated by Kennedy (in Kennedy and Anderson, 1938, 40). Thus the alkaline olivine basalts and dolerites of the Lower Carboniferous were succeeded by thoieiites and quartz dolerites at the close of the Carboniferous and again by olivine basalt magma in the early Permian.

CRUSTAL LAYERS IN NON-OROGENIC REGION

(*After MacGregor*, 1948; *Kennedy and Anderson*, (1938.)

(NOTE.—Magma may originate by crustal fusion at A, B, or C.)

GRANATIC LAYER (11 km.)		Essentially homogeneous
UPPER INTERMEDIATE LAYER (18 km.)	Tholeiitic (olivine-free or olivine-poor) basalt C	Essentially homogeneous
LOWER INTERMEDIATE LAYER (6 km.)	Alkaline —— B Olivine basalt A	Graded more mafic downwards
LOWER LAYER	Ultrabasic rock	

A new aspect of the problem was presented by Tilley (1950) who pointed out that tholeiitic magma was by no means confined to the continents and occurred in mid-oceanic islands such as Réunion and Hawaii where the absence of sial seems fairly certain. He considered further that tholeiitic magma might arise by crystallisation differentiation of sima at depth under suitable conditions. Since then there has been no major contribution to the problem, though Battey (1956) has established an interesting link between the tholeiitic and spilitic suites in New Zealand.

Let us now turn back to the state of the problem in 1928, when Bowen was dealing with the magma-types of Mull, in particular with the Hebridean Plateau or olivine basalt and Non-Porphyritic Central or Tholeiitic magma-types. Bowen (1928, 74-76), basing his calculations on the averages given in the Mull Memoir (Bailey and Thomas, 1924, 14, fig. 2), shows by means of an addition and subtraction diagram that the most basic material which can be subtracted from the olivine basalt magma-type to produce the tholeiitic consists normatively of olivine, diopsidic pyroxene, calcic plagioclase and magnetite. All these appear amongst the early crystallates of basalt and could take part in processes of crystal fractionation. This was considered to be a strong argument for the derivation of the tholeiitic magma-type from the olivine-basaltic by fractional crystallisation. Kennedy, however, following Wahl (1933, 239), drew attention to the world-wide distribution of the tholeiitic type which he considered to be primary.

Daly also criticised Bowen's arguments, pointing out that the average chemical compositions of the two magma-types as given in the Mull Memoir are not reliable since they include abnormal and amygdaloidal types and are not quoted 100 per cent anhydrous. Furthermore, the normative composition of the subtracted material shows an olivine and pyroxene too ferriferous and a plagioclase too sodic to appear amongst the earliest crystallites (Daly, 1933, 399; 1944, 1394).

Some years ago I recalculated the normative composition of the subtracted material, using weeded averages in which some additional analysis had been incorporated and the results are given below, together with Bowen's:—

	Bowen.	%	Walker.	%
Olivine	Fa_{37}	27	Fa_{28}	18
Pyroxene	$Wo_{51}En_{29}Fs_{20}$	7.5	$Wo_{22}En_{62}Fs_{16}$	17.5
Plagioclase	An_{63}	53	An_{80}	53
Magnetite	. .	4.5	....	10.5

The recalculated normative compositions are much more in keeping with the anticipated compositions of the earliest crystallates and Bowen's solution of the problem may be kept in mind therefore, pending the accumulation of further and more convincing data.

In conclusion, if Kennedy's postulate of two world-wide and primary basalt magma-types is valid, material transitional between the two fundamental types should be of relatively small bulk. Though no quantitative estimates are available this seems to be the case. Transitional provinces are scarce though they are to be found; e.g., the basalts of Central Victoria.

Having briefly surveyed the hypabyssal basaltic rocks of the world and the problems which they present, let us leave them with one aspect on which all petrological disputants will agree—the wonderful scenery of their terrains which finds its most spectacular development in the lovely island of Tasmania where R. M. Johnstone compiled his monumental work.

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WILLIAM BUELOW GOULD—CONVICT ARTIST IN VAN DIEMEN'S LAND

By

Isabella Mead*

(With 1 Plate)

When I came first to the Launceston Museum I found very many paintings by a convict named Gould. Very soon visitors were asking me questions about him and I proceeded to read what had been written. It seemed very little. In fact, it amounted to the notes that had been put together by Mr. Henry Allport for an exhibition of Tasmanian art held in Hobart in 1931. These notes were published in the "Mercury" newspaper and then put together in pamphlet form. Every subsequent writer on Gould has used them.

When people said, however, "When was he born? When did he die? Was he married? Did he leave any family? Did he paint only in oil?", I had to reply, "I do not know." I am still not certain when he was born, but I know when he died.

When people asked, "Where did Gould live?", I said, vaguely, "Hobart". Then, one day, looking through some records in the Museum, I found that William Buelow Gould was before R. C. Gunn,† Magistrate, here in Launceston, for being drunk. So he wasn't only in Hobart. He was also in Launceston and, I found later, at Macquarie Harbour, at Port Arthur, at Bridgewater, and at Jericho.

Then—Was he married? Did he have a family? Yes. Did he paint only in oil? No, he used watercolour too, much more effectively than he did oil.

So I got together gradually some kind of picture of this early artist.

Of Gould's early life very little is still known. Actually his name was Holland, not Gould.

He was born in Liverpool. Who his parents were is not known, for births were not registered at Somerset House until 1837 and even then were not obligatory; but an entry in Gore's Liverpool Directory of 1805, which reads "Peter Holland, Drawing Master", is suggestive.

Was Peter Holland, drawing master, Gould's father? He was probably educated at a local grammar school for he could read and write, an accomplishment rare amongst convicts 150 years ago.

Further details are given in the diary of Robert Francis Martin, 1st Officer in the ship which brought William Buelow Gould to Van Diemen's Land. He writes of him:—

> "This poor wretch is another example of the baneful effects produced by gambling. He has been a pupil of Mulreadys—his true name is Holland—his friends residing in Stafford are chinaware manufacturers.
>
> He got into a gambling set in Liverpool, lost his money and to redeem it and being fond of play he got initiated and became a regular member of the set of sharpers.
>
> In the course of his practices he came to London and was at one time intimate with the notorious Thurthill, the murderer, and all his gang.
>
> He painted at times for Ackerman in the Strand and got transported for some petty theft which his vices and necessities drove him to commit".

In an attempt to verify this story which Gould told, a letter was written to the Royal Academy of Arts who were unable to illuminate the story at all. William Mulready, R.A., taught drawing throughout his life, but as far as is known, no list of his pupils exists. Ackerman came to London as a coach designer, opened a print shop, and published numerous illustrated books.

Dr. C. Craig has in his possession an oil painting which suggests very strongly the Ackerman influence.

Tradition says also that Gould worked at flower painting at Spodes. Spodes say that it is likely that Gould did have some of his early training with them and an examination of various native flowers which Gould did in Tasmania reminds one immediately of exquisite china. But Spodes say also that their records were few between 1770 and 1850; also, as they were not considered of historical value, they were destroyed.

It was Josiah Spode who, in England, perfected bone china about the year 1805. This china was more translucent than anything which had been produced previously and was very suitable for decoration. To Josiah Spode England owed the

* Mrs. Mead, a former Director of the Queen Victoria Museum, Launceston, Tasmania, read this paper to the Royal Society of Tasmania, Northern Branch, in 1958.

†See notes at end of paper.

great reputation she obtained as being the only country manufacturing this beautifully decorated type of porcelain.

So here we have a man—educated, probably apprenticed to Spodes, learning their exquisite brushwork and the use of colour. Then, learning from Mulready, who taught drawing and exhibited at the Royal Academy, then working for Ackerman, who settled in the Strand and established art lithography in England. So Gould should have brought to Van Diemen's Land a rich inheritance—all that he had learnt from Josiah Spode, the finest of china manufacturers, and from Rudolf Ackerman, the finest printer and art producer of his time.

Why did Gould come to Van Diemen's Land?

The beginning of the trouble was probably when he went to London, made the wrong friends, and got in with the notorious Thurthill. John Thurthill was tried for murder in 1823 and when he was arrested the authorities also arrested any of his associates they could find. At least three were tried and everyone in sight was examined. Perhaps Gould became frightened at this time and left London, going back to his friends in the pottery counties, hoping they would help him to find work; but perhaps, too, they were too frightened to be associated with him after his life in London.

Unable to find work he found himself transported to Van Diemen's Land, leaving behind him a wife and two children in Burslem.

Let us look at the portrait of William Buelow Gould which hangs in the Tasmanian Museum.*

This portrait shows him as quite a well dressed man-about-town and was painted probably about 1845 when Gould was 45 or 46 years of age. Since we have in the archives an official description of him about this time, let us read it in conjunction with the portrait:—

> *Head,* large, long; *forehead,* low; *eyes,* grey; *complexion,* sallow; *hair,* dark-brown; *visage,* narrow; *eyebrows,* dark-brown; *chin,* small; *nose,* aquiline.

Let us turn back to the time of his arrival in Van Diemen's Land twenty years earlier. These records show that Gould's convict number was 521. He was five feet five inches in height, age 26, a painter by trade. His native place was Liverpool.

On the 7th November, 1826, after being in the Town Gaol for three months, he had been charged at the Northampton Quarter Sessions "with force and arms stolen one coat". The sentence was "seven years beyond the seas".

He had a previous conviction for stealing "colours", presumably painter's colours. The charge for stealing the coat was *felony* and, unfortunately for Gould, this year, 1826, was the last year when *petty larceny* was *felony.*

Until he was due to leave England, Gould was detained in the hulks *Dolphin* and *York.* Here he stayed from November till the following August—nine months—when he was shipped to Van Diemen's Land in the *Asia* 3. This was the second ship of this name to leave England for this country within a month. This *Asia* was shiprigged, square sails on its three masts, and was of 523 tons, built Calcutta about 1811. She left Portsmouth on the 17th August, 1827, with 200 male convicts in the charge of Captain Boscawen. The *Asia* came again in 1841 and 1847. There were, altogether, three ships named *Asia.*

Gould was probably pleased when the actual day of sailing came. We do not know what his actual feelings were as he saw England for the last time, but a general description of the departure has been given by the First Officer of the *Asia* 3, whose diary is still extant. He writes: "Some cast a tearful eye and melancholy look", some "were too busy squabbling for rations that they did not seem to care", and "others were lying in the sun talking in slang gibberish of their many adventures".

The departure was witnessed by the Russian Squadron lying at anchor in the English Channel. The Russian Squadron was awaiting orders from the British Government to proceed to the Mediterranean to help England help the Greeks against Turkey in the Greek War of Liberation.

In ten days some of the convicts had become troublesome—sauciness being their chief misdemeanour. At the end of a fortnight the matter was more serious. A conspiracy was planned to take the ship, set the Captain and Officers adrift, and to sail for some part of South America. Reminiscent of Bligh, twenty years before. The plot justified the statement of the Portsmouth paper which wrote of the *Asia's* departure—"200 worse characters never left the country".

William Buelow Gould took no part in these intrigues. During the voyage out, Gould was evidently quite busy. He was entered on the ship's papers as a portrait painter and the officers were having their likenesses taken by him. Officer Alsop was the first—sitting in full tog. But after four days Mr. Alsop was very dissatisfied with the result, especially when his friends quizzed him on the caricature. Then the purser, Ellis, had his portrait painted. Two days later this was finished and judged by fellow officers to be a tolerably good one.

After this Gould began working at a portrait of the First Officer, Robert Francis Martin, but the motion of the ship became so strong that for nearly a week he was unable to proceed with it. Robert Francis Martin was not very happy about this portrait for, according to himself, it depicted him in one of his worst humours with a severe headache.

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* In previous literature, especially Early Art in Tasmania (Henry Allport, 1931); The Story of Australian Art (William Moore, 1934); Origins of Art in Tasmania (Rosamond A. V. McCulloch, 1948); and A Study of Australian Art (Herbert E. Badham, 1949), this man has been called *William Barlow Gould,* but all records show this to be a phonetical mistake.

The mistake was never made by the Tasmanian Museum, Hobart, and Miss Ursula Hoff, National Gallery, Melbourne, in "Meanjin" Winter, 1951, No. 45, Vol. X, No. 2, uses the name *William Buelow Gould* in her notes on the Jubilee Exhibition.

To the early inhabitants of Hobart Town, Van Diemen's Land, however, it is very probable that names did not matter much and *Barlow* would be near enough. According to himself, neither *Barlow* nor *Buelow,* nor even *Gould* was his true name, but *Holland.* But *William Buelow Gould* is the name used consistently both by the authorities at the time and by Gould himself and throughout this paper.

Gould then began what the men on board considered his best portrait, that of Captain Boscawen, the military captain in charge of the convicts.

Unfortunately, we do not know what has become of these portraits, but presumably some of these of the ship's officers would find their way back to England.

During the voyage, as well as painting portraits, Gould did flower studies and most of the officers agreed that he did his best work in this medium, and posterity has affirmed this.

A set of these flower studies was done for Dr. Fairfowl and one, a tulip, for the First Officer.

On his arrival in Hobart Town Gould had with him one drawing box, length 1 foot 1 inch, breadth 9 inches, depth 7 inches.

On Friday, the 7th December, 1827, after nearly four months at sea, the *Asia* 3 was nearing its journey's end and entered D'Entrecasteaux Channel. The run through the channel was delightful to those on board, with its picturesque bays and coves and high mountains in the background. Here and there was a cleared patch of land with the cottage or bark hut of a settler.

At six o'clock that Friday night they anchored near Battery Point.

Mr. O'Farrel, the Naval Officer, was first on board for reports. Mr. Rollo O'Farrell is, I think, an interesting character. He had been appointed Naval Officer by Earl Bathurst in 1825. Governor Arthur said he was ignorant of business of every kind and Rollo O'Farrell, who sounds an Irish adventurer, said he had come to Hobart Town expecting to run down smugglers, not to do an office job. However, he appears to have been very attentive to duty on this day.

At 5 a.m. the next morning, Mr. Kelly, the Harbourmaster, came on board. Then Captain Montague, Deputy Colonial Secretary, and Mr. Lakeland, Principal Superintendent of convicts, mustered the prisoners and inquired as to their receiving good treatment and full rations during the voyage. There were no complaints and the appearance of the convicts was very much praised by the colonial officers. The Historical Records say: "198 prisoners in a clean and healthy condition were disembarked".

This embarkation took from Monday to Thursday.

These convicts were found to be a very valuable set, most of them being from farm labouring—men much wanted in the colony. This is interesting when compared with the English report that "200 worse characters never left the country".

Of these 200 prisoners who embarked, 198 landed safely at Hobart Town after a trip of nearly four months, during which time there had been mutiny and very high seas. Of these 198 convicts, 171 were assigned to the service of settlers, 23 were employed to the public works, and four were invalids. Gould was to be employed on public works.

The official account of the arrival of the ship says: "The surgeon superintendent, Mr. Fairfowl, and the Master, Mr. Ager, appear to have paid every attention to their respective duties" and the Governor, Sir George Arthur, paid them some high compliments on the health and cleanliness of the men.

Although Gould's conduct was exemplary on the voyage (his report reads "Conduct again good"), it appears that his crime merited employment on public works and not assignment, so, after being paid his 6s. 10d. which had been retained for him during the voyage by Surgeon-Lieutenant Fairfowl, he was sent to the Brickfields.

This is a different occupation to that of painting, but there is a connection, and here again it seems to have been understood that Gould had had previous experience in potteries.

Within a few weeks of his arrival we find that the Colonial Engineer, John Lee Archer, is asking for permission for William Gould (No. 521 per *Asia* 3) and another convict to sleep at the Brickfields Hut so as to attend the "pottery oven occasionally at night". This request was submitted to the Lieutenant-Governor who ascertained that, up till 28th January, 1828, that is for six weeks after his disembarkation, Gould "hath not any offence recorded against him".

Two days later however, on the 30 January, the Principal Superintendent was obliged to note on the Certificate of Gould's good conduct that Gould was now in the Chain Gang charged with being drunk and that "he is a useful man to the Engineer in the new pottery, but I conceive he is a man of very bad character".

The particular offence that brought forth this statement was that on the 21st January he was in a public house called "The Jolly Sailor", then situated in Goulburn Street, Hobart Town, in a state of intoxication after 9 o'clock on a Saturday night (perhaps spending his 6s. 10d.) and the penalty was 14 days with the Chain Gang.

It would appear that Gould had become an habitual drinker and during the next few years we find that he is continually before the authorities. His subsequent dossier states that on—

17th June, 1828, he is committed for stealing a silver watch, the property of Maria Sarjeant. Pleaded guilty.

24th June, 1828, he is convicted for the above offence. Sentence, 7 years, to be served concurrently with his present sentence.

20th June, 1829, while employed on public works he is tried for passing a forged note of the Derwent Bank and subsequently destroying it to avoid detection. Sentence, 3 years to Macquarie Harbour.

At this time the brig *Cyprus* was employed in taking convicts to Macquarie Harbour. It was in her that Gould sailed on the 28th July, 1829, and became one of the figures in a world-known piracy.

The trip was unfortunate from the beginning. The ship was detained eight days at Recherche Bay. On the ninth day she drove from her anchors and put back to refit at Hobart Town. She then returned to Recherche Bay to pick up her anchors and was again weather bound. During this time a conspiracy was planned. Here we are only concerned with Gould's part in it.

There were 31 convicts on board, all in double irons. Fourteen of these did not join the mutineers and were put ashore, together with the captain, crew and the officers in charge of the convicts.

In organised attempts to obtain help, one party of five, including Gould, set off for the Huon River. They were later picked up in a state of exhaustion by a search party when they were twelve miles from its mouth.

Back in Hobart Town, five weeks later, on the 4th September, 1829, these five prisoners presented a memorial to Governor George Arthur praying him to "look into our case and be pleased to grant what indulgences your Excellency may think best".

The specific report on Gould says, "This man was particularly quiet and orderly". Governor Arthur said, the 7th October, 1929: "I have considered in council the cases of the prisoners who, being ordered to be moved to Macquarie Harbour by the *Cyprus* were put ashore when the vessel was seized by the convicts, and looking to the importance of holding out encouragement to good conduct in the prisoners under such circumstances of temptation as this mutiny . . . will approve of their being disposed of in the following manner". Most were to be assigned, including Gould.

Gould's assignment was to Dr. Scott, of Boa Vista. Dr. James Scott, a surgeon in the Royal Navy, was appointed as Colonial Surgeon to the settlements on the Derwent in January, 1821. In June of the same year he was married at St. David's Church by the Rev. Robert Knopwood to Lucy Margaretta, the only child of Lieutenant-Governor Davey.

It would appear that Gould was favoured in this assignment to such a prominent citizen in Hobart Town, but habitual drunkenness and the inevitable absence from work did not earn for him his master's approbation. In May, he was sent back to the Barracks.

Successive admonitions and reprimands on the part of Dr. Scott bore no fruit and Gould soon found himself in cells on bread and water, being lashed, at the treadmill, doing hard labour, and in the hulk chain gang.

There is a monotony about the offences—drunkenness, drunkenness, and being out after hours, drunkenness on Saturday and Sunday, absent without leave, absent without leave and going on the Derwent River without proper authority, absent without leave and found in the street in the company of a female servant—for this he was to be confined in the Prisoners' Barracks for three months.

Time and again he was returned to Dr. Scott, but hardly a month goes by during the two years that he is with Dr. Scott but he is before the Magistrate.

Gould's continual drunkenness and the resultant bad behaviour became too much for the Authorities and on the 7th September, 1832, three years after his first trip, he sailed, by order of His Excellency Governor Arthur, for the second time to Macquarie Harbour.

At Macquarie Harbour where, officially, Gould appears to have been the servant of Dr. de Little, he was employed mostly at drawing. We are fortunate that he was for, apart from the artistic quality of his work, he has given us a very clear photographic picture of how Macquarie Harbour looked at this time.

In the "Penal Settlements of Van Diemen's Land, Macquarie Harbour, Maria Island, and Tasman's Peninsula" by Thomas James Lempriere, reprinted by the Royal Society of Tasmania (Northern Branch) 1954, p. 13, is found a detailed and interesting account of the work of Captain Butler, Commandant, 1825-9.

Lempriere tells us that Captain Butler left nothing to his successors to perform and it is interesting to compare his description of the Settlement with detailed watercolours by Gould, the originals of which are held by the Mitchell Library.

These watercolours came to the Mitchell Library with the G. A. Robinson Collection. They are clear in colour and detail and the drawing is exact in the then topographical style.

Here I would like to refer to two other sketches by Gould which also came back to Australia as part of the G. A. Robinson Collection. One is of "Towtrer", signed W. B. Gould Del., and the other is of a group of six aborigines. In both of these sketches the aborigines are wrapped in white shrouds.

G. A. Robinson, Conciliator of the Aborigines, was at Macquarie Harbour early in 1833 and appears to have called there several times during that year. Commandant Baylee was, however, so busy closing down the settlement that he appears to have had little time to report fully on Robinson's movements. Robinson was, at this time, gathering in the aborigines prior to their removal to Flinders Island.

On the 20th June Robinson arrived back from one of his excursions, bringing with him "seven aborigines, the last of the Port Davey Tribe". Commandant Baylee wrote to Mr. Burnett, Colonial Secretary, advising him that these would be embarked on board the brig *Tamar* for Hobart Town via Port Arthur. It was probably at this time that Gould's drawings were done, for he returned to Hobart Town on the same trip of the *Tamar* as G. A. Robinson and the aborigines.

Some of the best of Gould's work which I have seen is this which he did at Macquarie Harbour.

Perhaps it was one of the few times when liquor was hard to obtain and one report does say that he was sent to paint the place.

Mr. Henry Allport, of Hobart, has a most delightful sketch book of the fish and shellfish found at Macquarie Harbour. As Mr. Allport says, "Each study is an exquisite example of water colour art", Many of them are signed by Gould, and have obviously been done by the same hand, and on several pages there is a pencil note at the bottom, "Dr. de Little, Macquarie Harbour".

Mr. Henry Allport tells me, also, that a series of native birds and native flowers in a sketch book, possibly painted by W. B. Gould, was sold in Hobart about 1890.

The late W. B. Beattie said that he had seen one of these sketch books and that it was then owned by a woman in New South Wales.

An oil painting, "Macquarie Harbour", in the Tasmanian Museum, was probably painted at this time also. After nine months here, Gould was sent back to Hobart Town in the brig *Tamar* on the 22nd June, 1833. In the accompanying list of prisoners signed by the Commandant, the entry referring to Gould reads:—

> *No.* 521; *Name,* William Gould; *Ship from Europe, Asia; How employed,* Drawing, &c. *Remarks*: Returned to Hobart Town, having completed the work he was sent down for.

There seems to have been some lack of co-operation between Hobart Town and Macquarie Harbour on this point, for the Governor's comments on "what Gould was sent down for" are "Gould is a very drunken and dangerous person to be in Town." He was not sent to Macquarie Harbour to do any work, but was to be removed there for being drunken and dangerous. By His Excellency's Order, "He should be removed to Port Arthur", and then comes Governor Arthur's reproof: "In the event of any men being sent up without instruction, be so good as to refer to the Principal Superintendent for his opinion how they should be disposed of". Initialled G.A., 19th July.

Commandant Baylee complained frequently that he had received "no instructions". When Dr. de Little, Gould's master, arrived he was not put in charge of the hospital and surgical stores as he thought he would be because Baylee said he "had received no instructions". But communications between Macquarie Harbour and Hobart Town were few. When James Backhouse arrived there he was given a great welcome, for they had had no news of Hobart Town for more than three months.

So the following month finds Gould at Port Arthur ("this man should be removed to Port Arthur"). He arrived there on the 16th August, 1833, in the Government brig *Isabella*.

In a return six months later, 31st March, 1834, Gould is listed as house servant to the Assistant Surgeon, Thomas Coke Brownell.

Thomas Coke Brownell was replaced by John McBraire in July of the same year, and probably Gould was transferred to him. We do not know what opportunities Gould had for painting at Port Arthur, for O'Hara Booth's discipline was very strict, but a note referring to two of Gould's fish studies in the Beattie Catalogue says, "These were painted by Gould when he was at Port Arthur".

Mr. Sharman, State Archivist, has worked through the lists of convicts at Port Arthur during this period, through the Commandant's letters forwarding convicts back and acknowledging the arrival of convicts, and through the Returns of Punishments, but, apart from Gould's assignment to Thomas Coke Brownell, his name is not mentioned.

Gould would normally have received his freedom in 1834, his original sentence being for seven years, but, because of the concurrent sentence passed upon him in the Supreme Court for stealing a silver watch eighteen months after his arrival, the certificate was not issued until the 25th June, 1835, which would mean that he was at Port Arthur for nearly two years. The late J. W. Beattie says that he received his "Certificate of Freedom" at Port Arthur.

With this certificate, William Buelow Gould came north to Launceston and entered into written agreement with Henry Palmer. Henry Palmer was a coachbuilder, at first in Elizabeth Street, Launceston, and then, from 1834 onwards, in York Street.

In return for the stipulated wages, clothing, food, &c., Gould undertook to paint armorial decorations on the carriages of the wealthy merchants and landlords of Launceston Town. Having worked for Ackerman he would be very familiar with this work.

This arrangement, however, lasted but two or three days and his employer, evidently very distressed at losing labour, then hard to get, especially for such a specialised job as armorial painting, threatened in a public notice in the Launceston "Advertiser" to have a warrant issued for his arrest if he did not return. This reads as follows:—

> "Whereas, a man named William Gould, by trade a painter, and artist, recently from Hobart Town, with a Certificate of Freedom, entered into a written agreement to serve the undersigned for a period of six months, on stipulated wages, and after obtaining a considerable advance in new clothing, &c., absconded a fortnight ago, having remained only a few days in his employment. Now, this is to give notice, that any person in whose employment he may be found, will be proceeded against according to law, and should this meet his eye he is hereby informed that if he does not immediately return to perform his engagement a warrant will be issued for his apprehension.
>
> Henry Palmer,
> Launceston,
> October, 14, 1835".

"Launceston Advertiser", 22nd October, 1835.

Gould did return and the following month, on the 21st November, 1835, when the "Bushrangers, or Norwood Vale", a melodrama written by Henry Melville, was played in Launceston for the first time, Gould is featured as the artist who has done the scenic painting.

Dr. E. Morris Miller in "Pressmen and Governors", 1952, p. 50, has given us a description of this melodramatic play. It is the first dramatic piece on an Australian theme printed and published by an author living in Australia and was played in Launceston. It was really a play of one act, divided into three with thirteen scenes. A settler is attacked by bushrangers but is saved by his daughter's lover, of whom he has previously disapproved, and a native.

The advertisement in the "Cornwall Chronicle" says: "In the course of the piece will be exhibited an applicable and well-known scenic view of 'Molly York's Night Cap at Sunset', painted by Mr. Gould, an eminent Colonial Artist. Done expressly for this occasion".

A little money in his pocket, however, and Gould fell in with the bad companions who frequented one or other of the old pubs then in Brisbane Street. Not, I think, Dickey White's, but more probably the Currency House which was pulled down soon after, or the Joiner's Arms.

On New Year's Day, Gould was evidently celebrating too well and was found drunk in Brisbane Street, arrested and taken to the local watch-house which stood then on the present site of St. Andrew's Presbyterian Church, at the corner of St. John and Paterson Streets.

He resented this bitterly, and after much kicking and shouting for the Chief Constable he was handcuffed and chained by Constable John Williams. Constable Williams says briefly in his charge: "He was drunk".

Next day he was brought before the Magistrate, Ronald Campbell Gunn, found guilty, and fined five shillings. (This is the charge found in the Records of the Museum.)

Immediately on this he decided to shake the dust of Launceston from 'neath his feet and his employer, Henry Palmer, reported to the Magistrate on the 4th January that Gould was last seen four or five miles out on the Paterson's Plains Road (now St. Leonards) on his way to the country, taking with him money that he had collected for his employer.

The police apprehended him on the 26th February—nearly two months later—and sent for his employer. Henry Palmer said he was too busy to come that day for "he was attending on a gentleman and that a night's lodging would do Gould no harm". When the case was heard, on the 3rd March, evidently Gould had had more than one night's lodging, it was dismissed, the Prosecutor, Henry Palmer, stating he was in error.

By now Gould had almost completed his six months service with Henry Palmer which had begun on the 12th September, and the parting was probably mutual. Not being happy in Launceston, he returned, evidently, to his old haunts in Hobart Town, but immediately upon his arrival back, perhaps celebrating his return, with his last pay, he was in trouble. Again the charge is larceny, probably a drunken misdemeanour for, after being tried in the Supreme Court, he was found "not guilty".

In December of this year (1836), nine years after his arrival in Van Diemen's Land, he, as William Buelow, bachelor, took unto himself a wife, one Amy Reynolds, spinster. The banns were called and he was married in Old Trinity Church, Hobart, by the parish priest, Philip Palmer. Old Trinity Church is now the Supreme Court.

History has not revealed what happened to the wife and children left in England nearly ten years before, but Van Diemen's Land was a long way away and news travelled very slowly, if at all.

After his marriage, Gould appears to have endeavoured to earn an honest living, but, having probably earned a name as a ne'er-do-well around town, this was difficult. He finds himself accused of crimes which he may or may not have committed, including a charge of stealing an engraving, for which he was committed for trial.

But the attempt at reformation was evidently sincere and for the next eight years he keeps out of serious trouble. Most of his Tasmanian painting which is about at the present time seems to have been done during these years and includes the self portrait which is hung in the Tasmanian Museum.

It may be noted here that the many examples of Gould's work held by the Queen Victoria Museum, Launceston, Tasmania, were collected by the late J. W. Beattie and came to Launceston when the collection was purchased by the Launceston City Council in 1936.

In spite of this period seemingly being Gould's most prolific in painting, it was not his best, and it is hard to know how he supported his wife and family. Virtually it would have been impossible for him to do so by painting, especially as tradition says his paintings were taken by publicans in lieu of payment of his drink bill.

By the middle of the 40's Gould is again in trouble with the authorities. In July, 1845, he is convicted of stealing a musical snuff box, valued at £3, again the kind of theft a drunken man would commit. For this he was given two years' imprisonment but again his term is commuted to six months, this time by the Lieutenant-Governor, Sir Eardley-Wilmot.

In spite of this preferential treatment, little more than twelve months elapse before he is again in trouble. This time it is for stealing a pair of razors valued at 2s. 6d. He was tried in the Supreme Court and sentenced to two years' hard labour.

This sentence evidently left his wife and family destitute and the necessitous state of Mrs. Gould led her to petition the Lieutenant-Governor, now Sir William Denison, for help. She says "That (she) petitioner is left wholly destitute with five helpless children without any means of support and have since that period (the imprisonment of her husband) been depending on the benevolent hand of a humane and generous public and petitioner has since been allowed a weekly donation of 2s. from the Benevolent Dorcas Society, which gratuity has ceased and was petitioner's principal dependence whose helpless family are now left without a home to suffer the pinching pangs of starvation . . . May they (the Legislative Council) be mercifully pleased to grant some trifling weekly allowance for the support of five of Her Majesty's helpless and starving subjects without whose assistance must inevitably perish".

This petition is supported by letters from E. A. Brown, 28 Patrick Street; J. T. Butler, J. H. Smales; and J. Montgomerie, Murray Street, the landlord of 24 Harrington Street where Mrs. Gould lived. Number 24 Harrington Street stood as part of Wilmot Terrace until a few years ago.

Gould, in spite of reprieves during other terms of imprisonment, appears to have completed this two years' sentence and was kept at hard labour at Bridgewater and Jericho.

This appears, however, to have been his last misdemeanour. Continual drunkenness and then hard labour evidently broke his constitution. Upon his release, I imagine, he hung around the streets of Hobart Town getting drink when he could.

The tradition that publicans locked him in a garret to paint for them in return for a drink probably dates from this period.

In January, 1852, Gould attended the wedding of a daughter, Dinah Buelow Gould, who married Thomas Smith at St. George's Church, Battery Point, Hobart.

But life for him was drawing to a close, and his end was miserable. Perhaps, like his contemporary, Thomas Griffiths Wainwright, he had been brought up in an artistic atmosphere where hulks, treadmills, chain gangs and hard labour were unknown.

William Buelow Gould, or Holland, died in his late forties or early fifties on the 11th December, 1853, in Macquarie Street. The cause of death is "natural causes". An obituary notice in the "Hobart Town Daily Courier", when such notices for other than the wealthy were rare, read:—

> "On the 11th instant, at his residence, Macquarie Street, Mr. William Burow Gold, aged 49 years. The funeral will take place on Wednesday next at 3 o'clock. Friends at a distance will please accept this notice.
>
> Monday, December 12, 1853 '.

I would suggest to you that, although the life of William Buelow Gould is a pitiful story of cruelty, hardness, sorrow and waste, brought about time and time again by his own weakness, he was not evil. Every report, after confinement, when drink would not be available, says "quiet and orderly" in conduct. Again: Conduct—jail, good; hulk, good; ship, good.

Arnold Shore writes: "Gould is certainly not the first artist to battle between alcohol and art. George Moreland, famous English farmyard painter, finished that way. Modernist French Utrillo is another".

Probably being of an artistic temperament, possibly brought up in an artistic atmosphere, Gould led a so-called Bohemian life. This brought him, on his own confession, in contact with evil companions of the type so vividly described for us by Charles Dickens.

After transportation, life in Hobart Town would do little to help him. We can imagine the evenings spent at the "Jolly Sailor" in Goulburn Street in Hobart Town in the 1830's. I would like to suggest here that the so-called Wainwright tavern sketches held by the Queen Victoria Museum, Launceston, could be the work of Gould. These tavern sketches are typical of the types that hung around Hobart Town at this time; these would be the people who would be his companions as he crawled from pub to pub.

Unfortunately, we cannot say that Gould made any new contribution to Australian Art, for his whole life in Van Diemen's Land militated against this.

He has left us, however, some beautifully executed flower studies which are unique. These belong to Miss E. M. Hugh Smith, England,* and I am much indebted to her for making them available. They include three sketch books of native flowers of Van Diemen's Land and are, as the inscription says. "copied from nature".

How many such studies were done by Gould I do not know, but these drawn 1830-1 are characteristic of his fineness of brushwork and of a minute finish which it would be difficult to excel.

These botanical studies are all named, and are signed "B." or "J.B.". It is almost certain that the specimens were named by James Backhouse, Quaker, missioner and botanist, who was in Van Diemen's Land from February, 1832, to November, 1834, and again from April to November, 1837. How James Backhouse came to name them is not quite clear but there is evidence that he and Gould travelled roads that converged quite often.

Clive Turnbull, in his introduction to the Jubilee Exhibition of Australian Art says: "Gould's skilful and often extremely attractive still lifes reminded the colonists of an older and more settled civilization". The Gould exhibited in the Jubilee Exhibition was the Still Life Study of Flowers and Fruit held by Sir Lloyd Jones. This was also included in the Exhibition which was sent to the United States and Canada in 1941. In it Gould shows an almost simple minded delight in colour and texture. His use of blue is also artistic and reminds one of the blue of the Dutch artists.

Arnold Shore says that this Dutch influence is very evident in Gould's still life studies, and I think that all artists would agree on this point. It is very reminiscent of the still life work done in Holland over a century ago. Holland is unique in having had over a century of still life painting. The 17th and 18th century was the time of the Dutch overseas discovery. Seagoing merchants brought back with them new and strange fruits and flavours which were displayed by the wealthier classes. Artists found in these newly-discovered things fascinating forms and colours. Simple studies of fish and dead animals, particularly hares, also gave pleasure to art patrons. This school of painting had much influence on English artists and was very popular with them. It would appear to have influenced Gould. All his studies of dead game—fish—flowers—all these when painted in oil have the same flat decorative touch of the Dutch School.

This influence could, however, not only have been one of taste, but also one of racial instinct coupled with his Spode training.

You will remember that Gould's real name was Holland. Possibly Holland was the country of his father's origin. During the 18th century there was considerable interchange in craftsmen and artists, especially in the pottery industries; also, again we are remembering the Spode tradition. An artist named Buelow might, quite easily sign himself "van Holland", as we might today sign ourselves "Australia" when in a strange country. As such he would be indexed on paysheets, &c. This could result in his being eventually known as Holland. There are many examples of this kind in history.

As we have been unable to learn very much either of Gould's background or of his work in England. we cannot tell how far he fulfilled or fell short of any promise shown in his early years.

We cannot say, either, how far he was actually influenced either by the Dutch School, by Spodes, by Rudolph Ackerman, or by his teachers, possibly his father and then later Mulready.

With William Buelow Gould's death in 1853 the period of early art in this land almost finished. Not many of the early colonists who had pioneered art in this new colony of Van Diemen's Land lived after the turn of the mid-century.

Thomas Griffiths Wainwright had died in 1847; John Glover in 1849; Benjamin Duterrau in 1851;

*Since purchased by Queen Victoria Museum, Launceston.

George William Evans in 1852; William Buelow Gould in 1853. Thomas Bock lived until 1855.

It is perhaps fitting that it should be so, for in 1853 Van Diemen's Land began a new life as Tasmania.

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1. Gunn, Ronald Campbell, 1808-1885, was Superintendent of Convicts, Northern Division, and Police Magistrate, 1830-1836.
2. Boscawen, Captain E. P., Captain 40th Regiment, was in Hobart Town in 1828. He sailed for Bombay with a detachment of his Regiment in the *Royal George*, R. Embleton, Master, 1st March, 1829.
3. Mulready, William, 1786-1863, genre painter, taught drawing, illustrated children's books, exhibited at Royal Academy, illustrated the "Vicar of Wakefield", c. 1840. designed the first penny postage envelope issued by Rowland Hill, 1842.
4. Ackerman, Rudolph, 1764-1834. Art publisher and bookseller.
5. *The Jolly Sailor* was a Public House in Goulburn Street, Hobart. In 1835 the licence was held by Francis William Cobb. *H.T.G.*, 8 Oct., 1835, p. 828.
6. Arthur, Sir George, Governor of Van Diemen's Land, 1824-1836.
7. Macquarie Harbour, Penal Settlement on West Coast of Tasmania, 1824-1833.
8. Wilmot, Sir Eardley, Governor of Van Diemen's Land, 1843-1846.
9. de Little, Doctor. Arrived in Hobart Town in the *Cleopatra* in May, 1832 and went to Macquarie Harbour shortly afterwards, succeeding Dr. Dermer. He remained until the settlement was disbanded, and in 1834 succeeded Dr. Sharland at Bothwell. In 1838 he was found drowned and was buried in the Bothwell cemetery.
10. Denison, Sir William. Governor of Van Diemen's Land, 1847-1855.
11. Booth, Charles O'Hara. Commandant Port Arthur, 1833. 1844.
12. Port Arthur. Penal settlement in south of Tasmania, 1830-1877.
13. Smales, Joseph H., was a Church of England catechist. He was appointed as a "temporary clerk" at St. David's Church in 1833 and as catechist at Trinity Church, Hobart, 1853. He was ordained as a deacon in 1866 "after 33 years' lay ministry".
14. Montague, John, 1797-1853. Came to Van Diemen's Land in 1823 with Governor Sir George Arthur.
15. The Brig *Cyprus*, 108 tons, was purchased in August, 1826, by Governor Arthur for the penal settlement of Macquarie Harbour. The cost was £1,700 sterling.

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SEA LEVEL CHANGE AND SHORELINE DEVELOPMENT IN SOUTH-EASTERN TASMANIA

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(With 5 Text Figures)

ABSTRACT

The existence of shore features associated with two older, higher sea levels has been an important factor in the development of the present coast of south-eastern Tasmania. The Llanherne level lies between 12 and 15 feet above present sea level and is probably related to the last interglacial or an interstadial time. The Milford level is two to three feet above present sea level and is almost certainly post-glacial in date. The nature and effect of marine action at the two levels is discussed in relation to Seven Mile Beach spit, Ralph Bay Neck and Marion Bay spit.

INTRODUCTION

The major outline of the coast of south-eastern Tasmania results directly from the world-wide, post-glacial rise of sea level, which drowned the Derwent and Pittwater valleys and flooded the lowlands of Ralph, Frederick Henry, Norfolk, and Blackman Bays. That such a submergence took place is generally accepted, although its exact extent has yet to be determined. Sections across the Derwent near Hobart, published by Lewis (1935), show a mud-filled channel cut in bedrock to about 150 feet below present sea level, thus implying a strandline at least about 200 feet lower than that which exists today. A clearly-defined, submerged, mud-filled and apparently river-cut channel runs from east to west from Norfolk into Frederick Henry Bay, reaching a maximum depth of 132 feet immediately to the north of Slopen Island. Since it contains an unknown amount of mud, its original depth can be assumed to be something in excess of this (Admiralty Chart No. 809, Frederick Henry and Norfolk Bays).

Such evidence for previous low sea levels probably relates in the main to a general average Pleistocene low sea level, which approximately may have been attained during each glacial. Detailed stratigraphic investigation in suitable localities will be necessary before the full sequence can be worked out and this has not yet been attempted. However, for the purpose of interpreting the present shoreline, it is sufficient to appreciate that the last major shift of sea level was an upward one, that the main coastal outline results from the drowning of a former sub-aerial landscape and that it was this event which initiated the present cycle of marine erosion. Since that time the sea has modified the initial coastline by the cutting back of headlands and the building of spits and tidal marshes, and, simultaneously, smaller changes of sea level have occurred. It is with the interrelationship between these marine processes and these later and smaller sea level changes that the present account is concerned.

THE LLANHERNE AND MILFORD SEA LEVELS

Two recent higher sea levels have played a large part in determining the morphology of the present coast. Features resulting from these two levels are well developed in the vicinity of Hobart airport and this provides a convenient "type locality". At the higher level, high-water mark stood at between 12 and 15 feet above that at present and it is proposed to designate this the Llanherne level, since the small hill of that name, on which the airport control tower now stands, then formed an island. To the east of here, at Milford, the lower level is represented along the shores of Pittwater by old vegetated cliffs fronted by narrow raised beaches. A part of these can be seen from the old road on the Bluff at the western end of the Sorell causeways. It is proposed to call this the Milford level and high-water mark at this time was between two and three feet higher than at present. These two old shorelines can be detected throughout south-eastern Tasmania. Where they occur their height has been checked using a level and staff and relating present and past high-water marks. Tidal range along these coasts is about three to four feet, ecept in Norfolk Bay where it rises to six feet.

Lewis (1935) discussed Tasmanian raised beaches and river terraces and attempted correlations of each with his scheme of Tasmanian glacial stages. His lowest raised beach at 5 to 15 feet above high-water mark was thought to date from the last interglacial. Later (Lewis, 1946) he named this the Ralph's Bay stage and referred the next level at 50 to 60 feet to his Cambridge stage. Lewis's Ralph's Bay stage terraces seem to correlate generally with the Llanherne level and he does not seem to have recognised the lower level as distinct, although he does appear to have noticed its

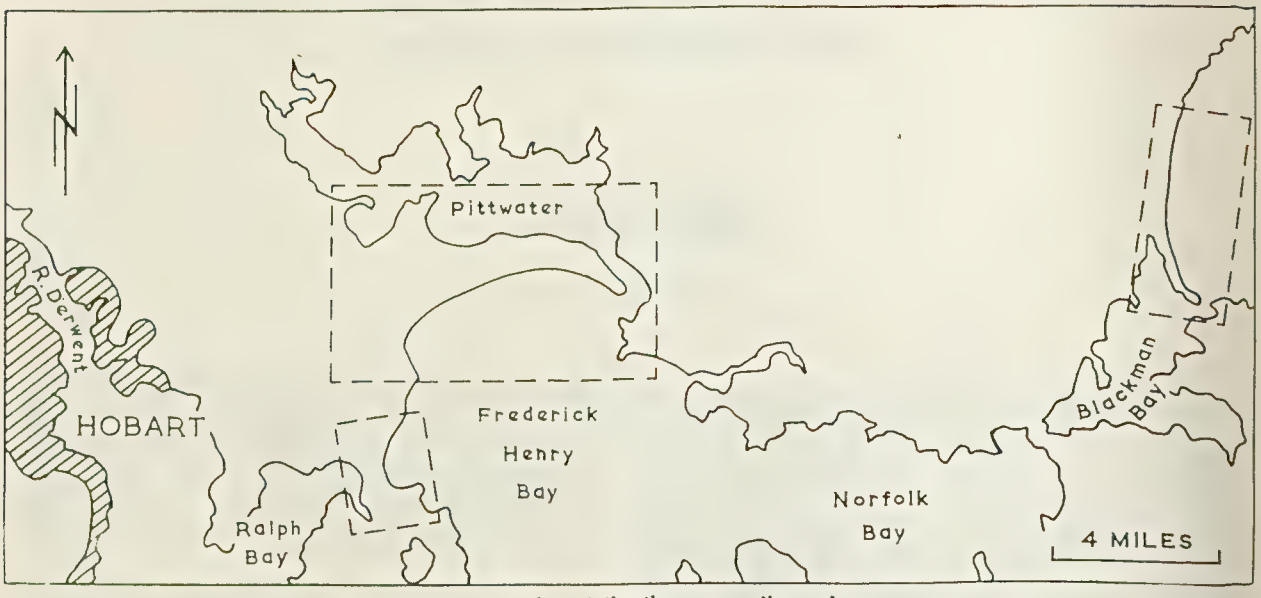

FIG. 1.—Location of the three areas discussed.

existence. For instance, in referring to the South Arm peninsula, he mentions (1946, p. 154) that "a raised beach generally five feet high skirts the whole coast, but at Maria Point this is 15 feet above sea level." On the other hand, he later (p. 209) referred to his Cambridge stage the raised beaches tying Llanherne island. In view of this confusion and uncertainty, Lewis's nomenclature is not used here.

The general nature of the features associated with the Llanherne and Milford levels and their influence upon the development of the present shoreline can best be discussed by reference to three major structures, Seven Mile Beach spit, Ralph Bay Neck and Marion Bay spit, the location of which is shown in Figure 1.

SEVEN MILE BEACH SPIT

The large spit of Seven Mile Beach is a mid-bay bar lying at the head of Frederick Henry Bay and almost closing the Pittwater ria. The Llanherne shoreline ran from the eastern end of the old Cambridge airfield to the eastern foot of Single Hill (Figure 2A). The Bluff and Llanherne formed two islands, probably tied to this shoreline by a complex tombolo on which low frontal dunes developed. At the eastern, less sheltered end of the tombolo, blow-outs occurred and parabolic dunes moved over the southern slopes of the Bluff. The platform now extending seaward from the Llanherne shoreline, and on which the new Hobart airport has been built, appears in the main to be a depositional one of sand and shell. Both marine and aeolian sands belonging to this level have been well podzolised and Loveday (1957) in a soil survey of the region, classified them as "podzols on cover sands".

At the time of the Milford shoreline, the former islands of Llanherne and the Bluff were incorporated into a peninsula, along both northern and southern sides of which the sea cut low cliffs (Figure 2B). On the southern shore, frontal dunes were built up, although subsequently these have been much eroded by the small creek which now runs through from south-west to north-east. This creek, in addition to carrying tidal flood and ebb, drains a large, shallow pool, which forms on the Llanherne surface south-west of the airport at times of heavy rain.

Between the Milford shoreline and the present-day shoreline has grown up the Seven Mile Beach spit and factors influencing its alignment have been discussed elsewhere (Davies, in press). That the spit appears to have grown from west to east seems to be due to three main factors: the presence of the initial peninsula on the western shore of Pittwater, the prevalence of beach drifting from west to east under the influence of local waves generated by south-westerly winds, and the decrease in wave height and consequently berm height from west to east caused by refraction of the dominant swell. This last effect, which may be demonstrated by the construction of refraction diagrams and by inspection of berm heights and beach cusp dimensions on the present beach, is probably the most important, for beach drifting appears to be negligible and the western peninsula is only there because the Llanherne tombolo also grew from the west, presumably under the influence of the other two factors. Bascom (1954) has discussed the control of stream outlets by wave refraction.

The present spit is composed of a series of between 40 and 50 sand beach ridges, lying generally parallel with the present shore. A statistical analysis of a cross profile of these (Davies, 1958) suggests that, while they were being formed,

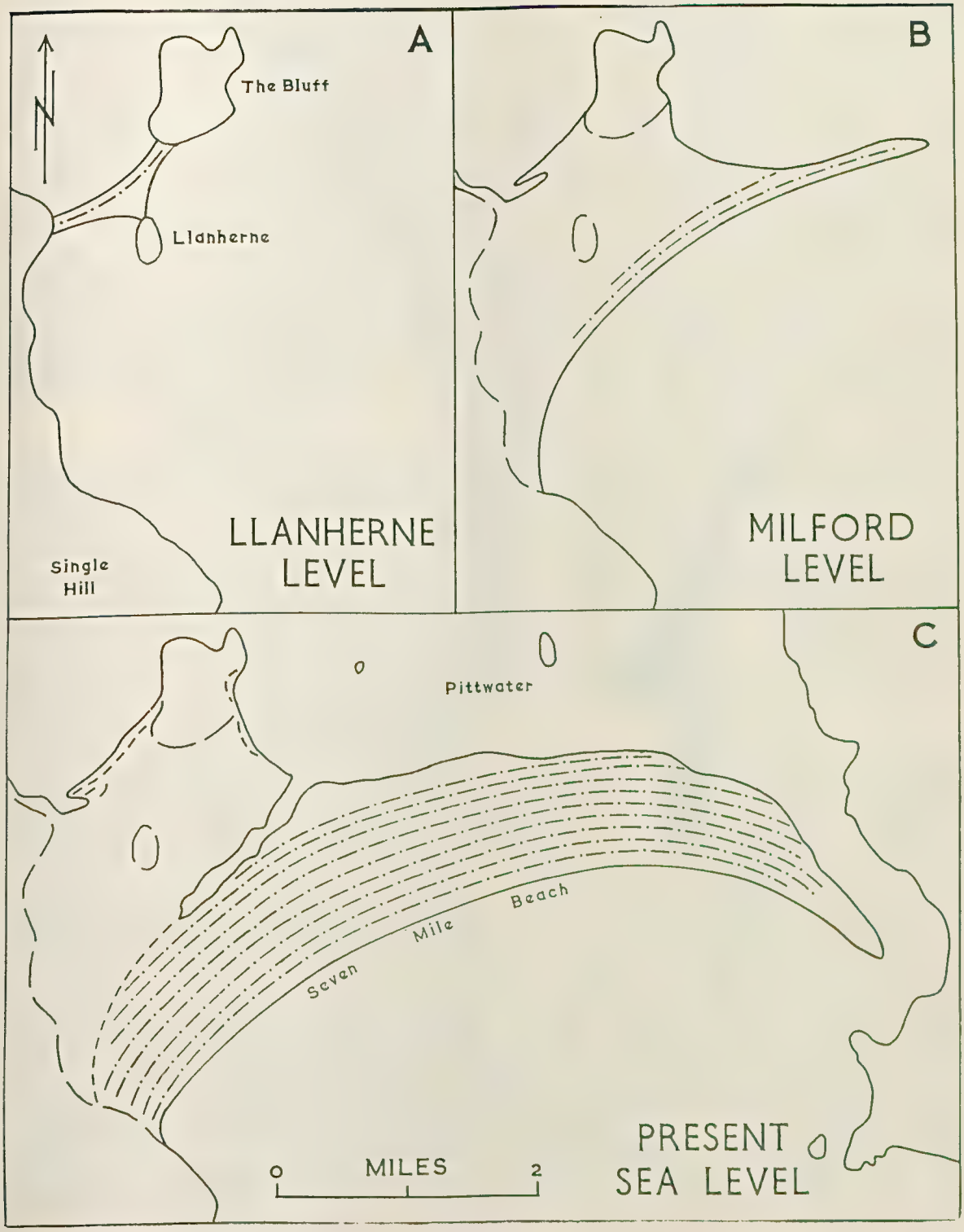

FIG. 2.—Evolution of Seven Mile Beach Peninsula. The "dash-dot" lines indicate the position of foredunes and beach ridges, but on the present-day spit only every fifth ridge is shown.

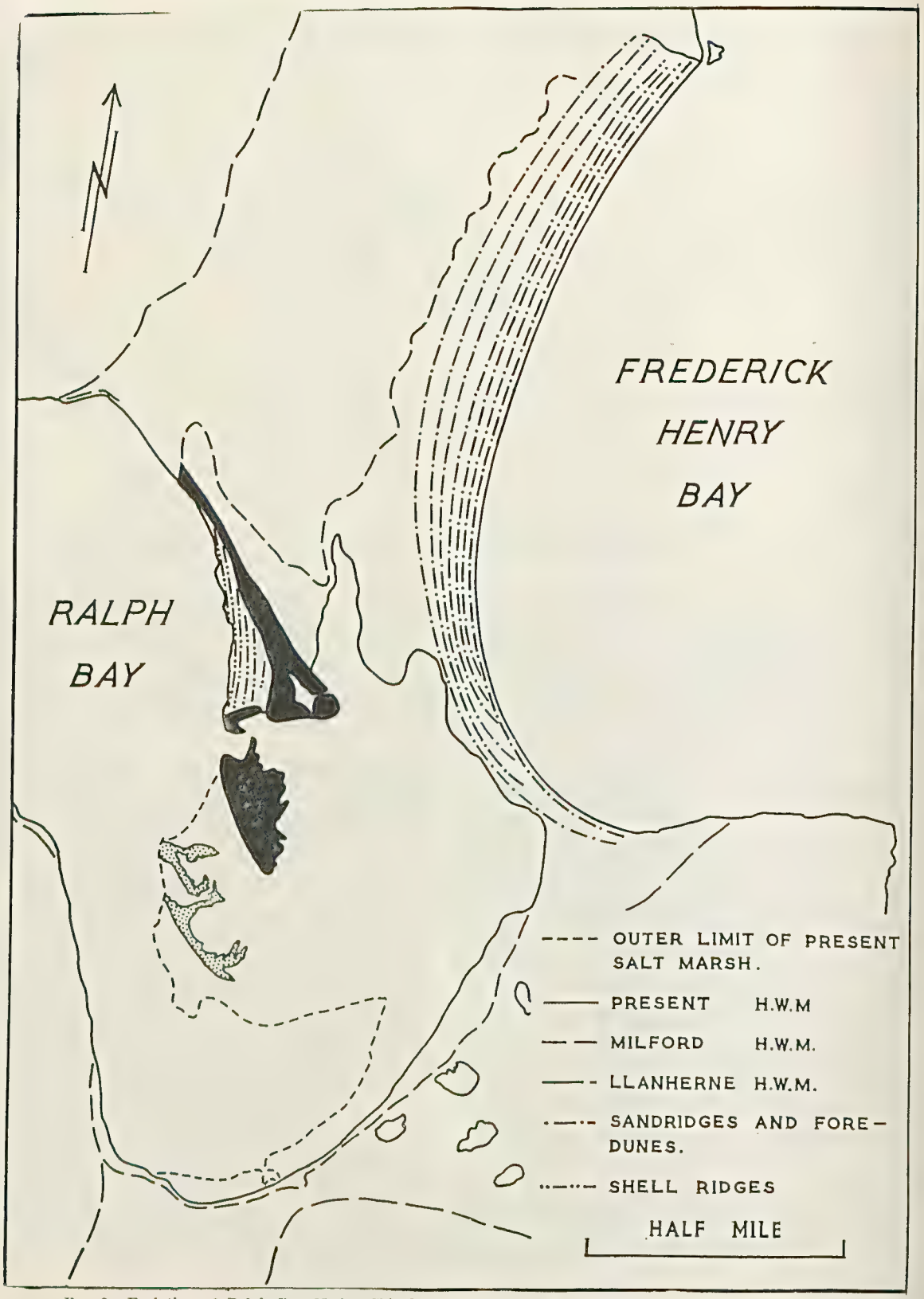

FIG. 3.--Evolution of Ralph Bay Neck. Shingle structures are shown in black; shell structures stippled.

sea level, or at least high-water mark, fell by about three feet. It seems clear that they were formed as the sea fell from the Milford level approximately to where it lies today and the field evidence is consistent with this conclusion. Loveday (1957) grouped Milford dunes, beach ridges and present-day dunes under the heading of "recent sands," although he noted that podzolisation is proceeding in those sections furthest inland which "it can be assumed . . . will eventually lead to formation of a profile similar to that described for the podzols on cover sands" (under which heading the Llanherne dunes and beaches are grouped).

A similar sequence of features can be seen on the north from the Hobart-Sorell road near the boundary of the Llanherne airport. South of the road is the line of Llanherne dunes, recently cut through in the laying down of the new airport runway. To the north of the road is the Llanherne beach, which is succeeded by the Milford shoreline crowned with a narrow strip of low dunes and succeeded in turn by the raised Milford beach and present-day salt marsh.

RALPH BAY NECK

The South Arm peninsula consists of a series of former isiands tied by marine deposition at several former high sea levels. Ralph Bay Neck provides a good example of the influence of the two most recent of these high sea levels on the development of the present coast (Figure 3).

The Llanherne shoreline can easily be traced from the southern foot of Single Hill to a point just west of the Hobart-South Arm road, although in two places it is somewhat obscured by alluvial fans which have been built across it. On the southern side of the Neck this shoreline is less distinct, but runs from Richardson's Hill to Mount Mather. At the Llanherne sea level then the Neck did not exist and a strait separated South Arm from the main part of Tasmania. Such a strait was also in existence in the early stages of the Milford sea level, although now more constricted. The Milford shoreline runs from the northern end of Roches Beach to Ralph Bay and forms generally indistinct low cliffs, a foot or two high, cut into the partly erosional and partly depositional platform left by the recession of the Llanherne sea. As in the case of the Llanherne shore, the Milford shore is not so distinct at the southern end of the Neck and there is no extensive platform intervening between the two levels as there is in the north. This is clearly to be correlated with the significantly greater exposure to wave attack in the north.

After some initial corrasion, the Miford sea began to build two spits across the strait, which must have been shallow at this time. One, on the Frederick Henry Bay side, was composed of sand and eventually grew so as to close the strait completely. At this stage it must have resembled on a small scale the bars tying the two halves of Maria and Bruni Islands today. Its establishment was helped by the formation of the second spit. This grew from a small promontary in the north-eastern corner of Ralph Bay and was composed of small shingle and shell. It reached only part way across the strait and its distal end became recurved and complex. The two spits must have grown up simultaneously and afforded each other mutual protection. Wave action in the sheltered north-eastern corner of Ralph Bay is very limited and the shingle spit rose very little above the Milford high-water mark. On the Frederick Henry Bay side, wave action is much greater and the sand spit grew to about six feet above the Milford high-water mark by dune accumulation on the wave-built bar. In between the two spits, salt marsh started to develop and to the south of the shingle spit is a group of banks of shingle and shell also related to the Milford level. They are now above high-water mark, although they lay just below the high-water mark of the Milford sea. One of them, to the east of the main road, has been quarried for its shingle content. These structures resemble mid-channel tidal banks, but it seems unlikely that weak tidal currents, such as those operating today, could move shingle and it is more probable that the banks are associated with a time just before the sand spit closed the strait, when stronger current action prevailed in the narrow opening.

Finally the sea dropped from the Milford level to approximately that of the present day. In doing so, it built a series of sand beach ridges along Frederick Henry Bay in front of the sand spit and a series of shell ridges on Ralph Bay in front of the shingle spit. These shell ridges have been obliterated to some extent by the building of the road across the Neck, but they can still be seen immediately north of the canal. Statistical analysis of the sand ridges indicated a drop in sea level of about two or three feet while they were being formed (Davies, 1958). At the same time the Milford salt marsh and mid-channel banks were uplifted and surrounded by new salt marsh developed at the present sea level.

MARION BAY SPIT

The spit at Marion Bay is about five miles long and almost closes off Blackman Bay from the open ocean (Figure 4). A narrow and changeable channel at its southern tip is kept open by tidal scour. Behind the spit, to the west, the Llanherne shoreline is plainly visible as a line of high cliffs cut into basalt and sandstone. In front of these cliffs is a platform comparable to that at the northern end of Ralph Bay Neck and to that on which the Llanherne airport stands. This terminates at its seaward end in low cliffs a few feet high cut by the sea at the Milford level.

It was at the Milford level that the modern spit first appeared. Initially it grew southward from an old headland of dolerite immediately south of the point where Bream Creek originally reached the coast. This first spit extended the full length of the present spit and salt marshes developed behind it at its northern end and in front of the low cliffs at the foot of the Llanherne platform. Later, as the sea fell from the Milford level, a raised sand beach and shell ridges broadened the old spit to the west (Figure 5) and new foredunes were added to seaward. In part the new dunes rest on a second spit emanating from a headland to the north of Bream Creek. The result has been that

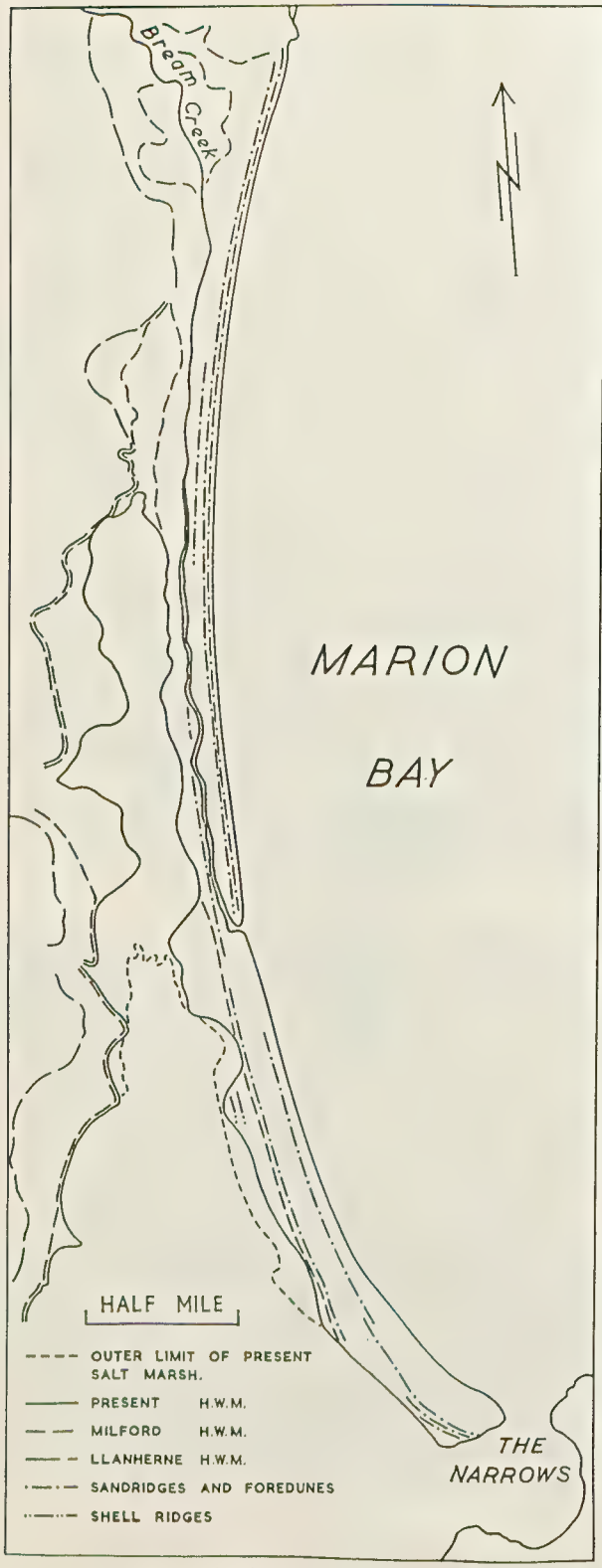

FIG. 4.—Evolution of Marion Bay Spit.

the creek has been sandwiched between the two spits and enters the sea in the middle of Marion Bay. The mouth of Bream Creek oscillates within about 600 yards along the shore, but, apart from this minor wandering, it has probably been stable throughout the life of the spit at present sea level. There is no evidence of an older mouth elsewhere and the present mouth is marked by blow-out dunes of varying ages, indicating a fair degree of permanence.

Convenient partial sections of the uplifted portion of the spit are now visible in the south-west where small storm waves, generated in Blackman Bay have eroded the inner tip of the spit into a straight line perpendicular to the direction of greatest fetch. Semi-concretionary sand with bedded shells, lying at and slightly above present high-water mark here, is representative of the spit at the Milford level.

Since the sea reached approximately its present level, extensive new salt marshes have been built and a short account of these is given by Curtis and Somerville (1947).

DISCUSSION

The Llanherne level is marked by strong cliffing and by relatively wide platforms, in part wave-cut. This is especially true of the Marion Bay site, which faces the open ocean. Depositional features at this level are limited. In any case, they are no longer in contact with the present shore and are not related to the present cycle of erosion. The importance of the Llanherne level lies in its effect on the landscape of the coastal zone rather than in its influence on the shoreline proper. Marine and aeolian sands associated with this level are well podzolised.

The Milford level is marked by weak cliffing and this mostly in unconsolidated materials at the foot of the Llanherne platforms. Associated wave-cut or wave-built platforms are virtually non-existent. Apparently, there was only a short period of corrasion at the Milford level before the building of spits and tidal marshes began. It is important to note that spit building began before the emergence from the Milford level. Some authors (for instance, Loveday, 1957) have taken such features as the Marion Bay spit as characteristic of an emerged shoreline, but in fact this spit had attained its present length (though not breadth) before the slight emergence took place. Similarly, at Ralph Bay Neck, the two spits which initiated the present isthmus formed before emergence and many other similar structures around the south-east coast, such as Eaglehawk Neck and the spit closing the southern end of Ralph Bay, are Milford features raised two or three feet to their present position. Seven Mile Beach spit is an exception in that, although an embryo spit was formed at the Milford level, the great bulk of the present structure accumulated during the emergence from that level. The building of spits to close re-entrants and of tidal marshes behind the spits is part of the cycle of erosion consequent upon submergence of a coastline. The slight emergence has only accentuated these features and to some extent speeded their construction.

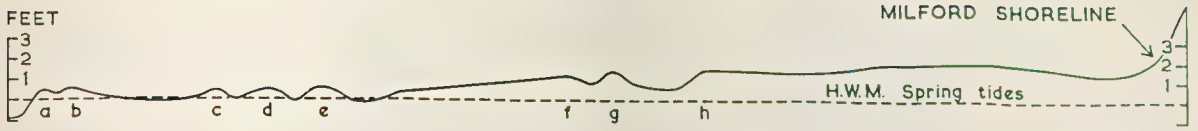

FIG. 5.—Cross profile of inner edge of Marion Bay Spit.

The letters indicate ridges, all composed primarily of the shells of *Eubittium lawleyanum* (Crosse) and *Assiminia brazieri* (Tenison-Woods).

It would be very difficult to interpret the succession of events between the initiation of the Milford sea level and the present as other than essentially continuous. In particular, the beach ridges and frontal dunes show a gradual transition in soil profile from the raw, calcareous sands of the present-day to the incipient podzols of the Milford level. There is no break other than possibly a recent one, indicated perhaps by the present erosion of ridges and dunes. But this break, if it has existed, represents only a very small interval of time and may be due to a slight contemporary submergence, or as suggested elsewhere (Davies, 1957), to an increase in storminess. In short, the present cycle of erosion started at the Milford sea level and has hardly been interrupted by a small emergence and possibly an even smaller and most recent submergence. If this conclusion is correct, then the Milford level must represent the limit of post-glacial submergence in southern Tasmania, which, by world-wide analogy, would date from about 7,000 to 6,000 years before the present. The relative freshness of features associated with the Milford level and the small amount of podzolisation which has taken place in the Milford sands are in sympathy with this.

In contrast to the relationship between the Milford level and the present, there is an evident break between marine processes at the Milford level and those at the Llanherne. No process initiated at the Llanherne level carried through into the Milford. In keeping with this, there is a pronounced gap between the degree of podzolisation of Milford sands and that of Llanherne sands. Loveday (1957) noted this and remarked upon it. The tentative inference is that the Llanherne level dates from the last interglacial or an interstadial of the last glacial age.

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Plate 1.

Fig. 1.—The Milford shoreline at the north-western corner of Ralph Bay Neck: a low, vegetated, raised beach of semi-concretionary shell and small shingle is being eroded at present sea level where wave action is now extremely small.

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THE GEOLOGY OF THE NEW NORFOLK-BLACK HILLS DISTRICT

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(With 2 Text Figures and 2 Maps)

ABSTRACT

The rocks exposed in the New Norfolk and Black Hills map squares are predominantly sediments of Permian and Triassic age, and dolerite of Jurassic (?) age. There are also three small masses of Tertiary basalt, and extensive river sediments along the valley of the Derwent. These latter are possibly of two ages—Tertiary and Pleistocene. The Permian sediments are mudstones, sandstones, and marine limestones, with a total thickness of nearly 1,200 feet. Glacial erratics are common in these rocks, but they become fewer toward the top of the system. The Triassic sediments are dominantly coarse, well sorted sandstones, with some shaley bands, which were deposited in a terrestrial environment, under warm, arid conditions. Their thickness exceeds 1,000 feet.

The dolerite is very extensive, and has a strong effect on the structure and physiography of the area. The form of the intrusions is in detail very irregular, but, viewed as a whole, the dolerite masses are approximately sill-like.

Tertiary faulting has also had some effect on the physiography of the area. The faults are approximately vertical, and appear to have been formed under tensional conditions. Most of these faults strike in a south-easterly direction, and a wide down-faulted block trending in this direction appears to have influenced the course of the Derwent River to the west of New Norfolk.

The basalt outcrops in three separate masses, each of which is close to one or more Tertiary faults, and it is thought that there were at least two, and possibly three, separate flows. The largest of the basalt masses, at the town of New Norfolk, probably changed the course of the Derwent River to some extent. The river sediments were in part deposited after the extrusion of the basalt, but some of them are probably older than the basalt. They consist of sands and gravels.

INTRODUCTION

The area under study consists of two ten-thousand-yard map squares and is bounded on the west and east by the grid lines 490000 yds. E. and 500000 yds. E. respectively and on the south and north by the grid lines 730000 yds. N and 750000 yds. N. respectively. The northernmost of the two squares will be referred to as the Black Hills square and the southern one as the New Norfolk square. The total area is approximately 65 square miles. The town of New Norfolk is about 20 miles from Hobart and is reached by means of the Lyell Highway, which is for this part of its length a sealed bitumen road.

Access to the New Norfolk square is very good, as there are a number of roads and vehicular tracks scattered through the area, which allow easy access to any part of the square. In strong contrast, however, is the Black Hills square, where much of the country is almost inaccessible. The only road passing through this square is the Back River Road from New Norfolk, one branch of which goes to Gretna, the other branch ending a little to the north-east of Black Hills. Apart from this road, there are some vehicular and foot tracks; and a Hydro-Electric Commission transmission line which runs almost north-south through the square.

The geology of the area was plotted onto aerial photographs of the Hobart and Brighton runs and then transferred to a base map using a rectiplanograph. The base map was prepared by the slotted template method, in conjunction with the base map for the Dromedary and Brighton squares, which were mapped by McDougall (1959*b*). The lay-down for the four squares was controlled by the use of twenty trig. points.

Heights were measured with an aircraft-type altimeter and were corrected for atmospheric variation by plotting diurnal variation curves. An Abney level was used to a small extent, when measurements outside the limit of accuracy of the altimeter (accurate to the nearest five feet) were needed.

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PHYSIOGRAPHY

The relief of the area is considerable, and with the exception of the valley of the Derwent River, very rugged. The highest point in the area is the summit of Mt. Dromedary, which is 3,245 feet above sea level, and the minimum height, at Boyer, is only very slightly above sea level. The high nature of the hills is in part a result of the resistance of the dolerite to erosion and this has also caused most of the streams of the area to be still in the mountain tract. The drainage of the area is controlled by two main physiographic features, namely the River Derwent, and the high dolerite ridge running north-west from Mt. Dromedary. This ridge forms a divide in the drainage system, the most important stream flowing north from it being Grahams Creek. There are three main creeks flowing south from the divide into the Derwent, and these are Belmont Creek, Johnnys Creek, and Back River. The main drainage north into the Derwent is provided by the Lachlan River and Sorell Creek.

The dominant feature of the drainage of the area is, of course, the Derwent River. This is a large river and at the town of New Norfolk it is about 150 yards wide. In this area it appears to have passed through a late valley tract or early plains tract in its development, but has since been rejuvenated, and is now eroding earlier flood-plain deposits.

The topography of the area is controlled to a considerable extent by the dolerite, which forms the major portion of the hills in the north of the New Norfolk square and in the Black Hills square. The resistant nature of the dolerite causes these hills to be quite rugged, and only in the actual valley of the Derwent has the dolerite a subdued topography.

Besides the dolerite, the two most extensively occurring rocks are the sediments of the Knocklofty Formation (Triassic) and the Ferntree Formation (Permian). Both these formations have horizons which form strong positive features, usually in the form of cliffs. In the Knocklofty there is a resistant band approximately 50 feet above the base, which forms cliffs up to 30 feet high. These cliffs are particularly noticeable around the hills to the immediate east of Magra. Other parts of the Knocklofty Formation also form high cliffs, under certain conditions, and the best example of these are the cliffs along the banks of the Back River, just before it joins the Derwent. The middle parts of the Ferntree Formation also form high cliffs in some places, the highest of these being along the banks of the Derwent, particularly at The Rocks. The upper and lower parts of this formation do not have such a positive outcrop and usually occur as scree material.

Of the other Permian formations exposed in the area, only the Risdon Sandstone outcrops at all strongly and this formation commonly forms low cliffs. Outcrop of the "Woodbridge Glacial Formation", the Grange Mudstone, and the Berriedale Limestone is usually very poor.

The development of the present topography has been mainly determined by the distribution of the dolerite and by the Tertiary faulting. The area can be divided into three broad regions, namely, the high dolerite hills composing the greater part of the Black Hills square, the wide valley of the Derwent, and the high dolerite hills at the extreme south of the area. The northern region owes its height partly to the resistant nature of the dolerite, and partly to the Tertiary faulting, which has raised the northern side. The high dolerite hills in the south of the area are also partly due to the transgressive nature of the dolerite intrusion and partly to Tertiary faulting, which here has thrown the southern side up. The central region, that of the wide valley of the Derwent, is a low-lying area between the two upthrown blocks. This down-faulted block seems to have controlled the course of the Derwent to the west of New Norfolk, but this will be discussed more fully under Structural Geology.

The basalt (especially the large flow at the town of New Norfolk) may have had some effect on the course of the Derwent. This mass of basalt probably diverted the Derwent to the north, where it eroded the high cliffs at The Rocks. The original course of the river was probably through the centre of the town, as indicated by the present distribution of the river sediments. However, this would mean that at least some of the river sediments are older than the basalt, and there is no direct field evidence to support this.

STRATIGRAPHY

Permian System

Berriedale Limestone

The oldest rocks exposed in the area belong to the Berriedale Limestone, which outcrops at 902319 (Hobart Sheet). (The Army system of co-ordinates has been used, the area being covered partly by the Military one-mile Hobart map sheet and partly by the Brighton one-mile sheet.) At this locality, the section is terminated at the base by the Tertiary Glen Fern Fault, and the Berriedale Limestone, which outcrops in a small quarry, is overlain by approximately 100 feet of Grange Mudstone. Below the Berriedale Limestone there is an interval of approximately 100 feet of no outcrop, which possibly represents the Nassau Siltstone.

The thickness of the Berriedale Limestone cannot be measured at this locality due to the poor outcrop. The formation is a dense grey foetid limestone, generally slightly sandy but containing patches of pure calcite. It contains rare quartz erratics, of the order of $\frac{1}{8}$ to $\frac{1}{4}$ inch long. The most striking feature of the rock, which is a calcarenite to a calcilutite, is the very great number of fossils it contains, mostly in broken fragments. Spiriferids and fenestellids are the dominant forms. Pectens up to three inches across are present, and there are a few small ramose stenoporids. One specimen of a planispirally coiled gastropod, probably *Warthia*, was seen.

Grange Mudstone

Only the upper parts of this formation are exposed in this area, the thickest section being on a hill slope commencing at 996345 (Hobart Sheet), where there are 90 feet of it exposed between a sill-like dolerite body below, and the "Woodbridge Glacial Formation" above. The top of the Grange Mudstone is marked by very coarse, very poorly-sorted sandstone, which has been taken as the basal member of the Woodbridge. Near the base of this section, the sediment is strongly baked by the dolerite intrusion and the greenish, cherty appearance, which is characteristic of the formation at a slightly higher level, is also probably a baking effect.

Near the base of the section, the sediment is a greenish-grey to buff-coloured fine-grained mudstone, generally well sorted and containing few erratics. Fenestellids and stenoporids are very abundant and spiriferids and *Strophalosia* are present but not common. Two species of small gastropod are present, one planispirally coiled and one trochospirally coiled; neither occurs commonly. About 50 feet above the dolerite, there are still some floaters of the green, cherty-looking rock, and some of these have a large amount of a white mineral which gives the rock a spotty appearance. In thin section, this rock is seen to contain abundant sub-angular to angular quartz grains, of silt size and smaller (about 50%). Of the remainder of the rock, prehnite forms a considerable proportion, having presumably been formed under thermal metamorphic conditions at the time of the intrustion of the dolerite. Near the top of this section, the formation is slightly coarser-grained, although it is still a mudstone. The character of the fauna changes slightly in the relative abundance of the different species. *Strophalosia typica* is quite abundant, and spiriferid brachiopods are also common. Of the latter the most characteristic is a small long-hinged species, which is unidentified.

In the section described above, fossils besides spiriferids and *Strophalosia typica* are rare near the top. A very similar fauna has been seen at the top of the Grange Mudstone at two other localities, 987322 and 991327 (Hobart Sheet). At 987322 the formation is a white even-grained mudstone, containing masses of *S. typica*. There are also a few fenestellids and ramose stenoporids and an occasional pectinacean. Other brachiopods are not common. At 991327, the formation is distinctly coarser-grained, and is almost a fine sandstone. It is richly fossiliferous, the most abundant species again being *S. tyica*, but here other brachiopods are very common. Of these, the long-hinged spiriferid mentioned above is the most common, and *Terrakea* sp. is also present. The thickness exposed at these two localities is about 50 feet, but the base is covered by younger river gravels, so the total thickness of the Grange cannot be measured here.

At 902319 (Hobart Sheet), above the outcrop of Berriedale Limestone, there is a mixture of boulders of Berriedale Limestone and Grange Mudstone and it is difficult to tell exactly how thick the latter is in this section. It has been estimated at approximately 100 feet.

"Woodbridge Glacial Formation"

This formation consists of a series of fine, medium and coarse grained sandstones, totalling about 270 feet, characterised by a large number of erratics. It underlies the Risdon Sandstone and overlies the Grange Mudstone. The composition of the formation is dominantly quartz, but in some of the more poorly-sorted, coarser bands, there are appreciable amounts of feldspar. The erratics play a major role in the composition of the rock, and they have a very wide range of size, from particles of medium sand size up to small boulders a foot or more in diameter. They are mostly quartz and quartizite, but erratics of schist, slate and phyllite are also quite common and there are rare granite pebbles. The colour is generally cream or buff, but in some cases it is pale-grey. The bedding is almost exclusively thick, but it does not outcrop strongly and for the most part the distribution of this formation must be interpreted from the distribution of float material.

Some horizons in the "Woodbridge Glacial Formation" are extremely fossiliferous, but the major part of its thickness is quite barren. The base is usually very fossiliferous, the best exposure of this horizon being opposite the Boyer factory, just south of the Lyell Highway, at 990327 (Hobart Sheet). Here were found pectinaceans (about two inches across), *Strophalosia typica*, various spiriferids (including *Grantonia* and *Neospirifer*) in large numbers, some small trochospirally coiled gastropods, and a few fenestellids and ramose stenoporids. The basal 50 feet of this locality are very fossiliferous, with very little change in the fauna from that described from the base. One addition to the assemblage at a higher level is *Dielasma*. Above the 50-ft. level, fossils become very rare, with only scattered fenestellids and spiriferids persisting for another 20 feet. The fauna at the base of the "Woodbridge Glacial Formation" occurs in a very coarse, very poortly sorted, whitish sandstone. It contains quartz and slate erratics up to one inch long, and these vary from angular to sub-rounded. The matrix consists dominantly of sub-angular quartz fragments with minor amounts of angular feldspar fragments. In some specimens (28156, U.T.G.D.) there is practically no finer material, but in other specimens, the amount of very fine-grained material (silt size and smaller) becomes quite large, and in specimen 28161, the whole matrix is fine grained. There is a wide range of sizes in the erratic fragments, which grade up from coarse sand size to pebbles an inch long. They are mainly quartz, but a few slate fragments are also present in most specimens. The fine-grained parts of the rock occur in small lenses, and are sometimes slightly better sorted.

Proceeding up the section opposite Boyer, the formation remains a coarse, poorly-sorted sandstone, but about 40 feet above the base, bands of slightly finer-grained sandstone begin to alternate with the coarse sandstone. The erratics also become a little more varied in composition

with some schist and granite pebbles up to three inches long. In this section, the basal member is approximately 40 feet thick and is overlain by a medium to coarse grained, poorly-sorted sandstone (although better sorted than the basal member), which contains numerous erratics up to ¼-inch long, and rare erratics up to an inch long. This member contains a few fenestellids and spiriferids in the lower 20 feet. The member is about 30 feet thick in this section, although this is only an estimate based on the distribution of float material.

The base of the "Woodbridge Glacial Formation" is well exposed in a section behind the Boyer factory at 987343 (Hobart Sheet). Here it has a very similar lithology to that described above, and contains numerous fossils, including pectinaceans and brachiopods. Amongst the latter there are some which are of the "martiniopsid" type and a very long-hinged spiriferid. At this locality the fossils are almost entirely confined to the bottom 15 feet and above this level the formation becomes slightly finer-grained and contains fewer erratics. The coarse sandstone in this section is about 80 feet thick (this includes both the coarse sandstone members described in the previous section).

In the Boyer section the basal coarse sandstone is overlain by a fine-grained, greyish sandstone, containing many small erratics about ⅛-inch long, and a few up to one inch long. This fine sandstone member forms a important part of the formation, and in the Boyer section it is approximately 110 feet thick. A quarry in this sandstone has provided good exposure at 982339 (Hobart Sheet). Here the member is a massively-bedded, fine-grained sandstone, buff to pinkish in colour. There are fairly large numbers of erratics, and these are nearly all in the size range ⅛ to ½ inch, although there are a few up to three inches long . This member is completely unfossiliferous.

Above the grey fine-grained sandstone member there is another coarse sandstone, which is poorly sorted and richly fossiliferous. It is a dominantly quartzitic sandstone, but contains small amounts of feldspar and argillaceous material. The particles in the matrix are mainly in the medium sand size range and are sub-angular to sub-rounded. The erratics, which are nearly all quartz or quartzite (apart from a few slate fragments), vary greatly in shape, size and roundness. This member is 70 feet thick in the section behind Boyer, where the base of the outcrop is at 979339 (Hobart Sheet). It is very fossiliferous, with a dominantly molluscan fauna. Large pectinaceans occur frequently and *Stutchburia* is a characteristic genus. Rare "martiniopsid"-type brachiopods have also been found. The lack of outcrop of this member is often accentuated by the presence of large amounts of scree material from the overlying Ferntree Formation and, as a result, it has only been examined at a small number of localities. Large amounts of float occur at 999452 (Brighton Sheet) and here there are numerous fossils, including *Stutchburia*, *Warthia*, a small species of *Myonia* and various spiriferids.

The topmost member of the "Woodbridge Glacial Formation" is a band, about 20 feet thick, of fine-grained sandstone or mudstone (the lithology varies slightly at different localities). In the section behind Boyer, this member is a pale-brown mudstone, mainly well-sorted, but containing an occasional erratic from one to two inches long. This member is also extremely fossiliferous, the two most characteristic species being *Strophalosia ovalis* and *Terrakea solida* (N. G. Lane, pers. comm.). These occur in great numbers, generally preserved as internal and external moulds. Many other species occur in this member, including spiriferids (rare), *Protoretepora ampla* and other fenestellids, and a small trochospirally coiled gastropod (also rare).

This member does not have a strong outcrop, as it is easily weathered, and is often covered by scree from the Ferntree Formation.

The total thickness of the Woodbridge in the section behind Boyer is approximately 290 feet .

Well exposed sections of the "Woodbridge Glacial Formation" are not common, but two sections, apart from the ones described above, have been measured. The first of these is exposed on a steep hill slope along the north bank of Mount Rivulet at 998313 (Hobart Sheet). At the base of the section here, there is a sill-like dolerite intrusion into Grange Mudstone. Overlying the baked Grange, is a coarse, poorly-sorted sandstone containing numerous brachiopods, which has been taken as the basal member of the "Woodbridge Glacial Formation". Fenestellids, stenoporids and pectinaceans also occur, slightly above the base. This member grades up into a medium to fine grained sandstone which is poorly sorted and contains an appreciable amount of clayey material. It is buff-coloured and erratics are large but not numerous. The boundary between these two sandstones is not exposed. Above the fine-grained sandstone is another coarse-grained sandstone, which is whitish and contains many erratics which are mostly less than ¼-inch long. This member is probably equivalent to the upper coarse sandstone member in the Boyer section, but no fossils were found in this locality. In this Mount Rivulet section there is no outcrop of the top member but several large boulders of mudstone containing *Strophalosia* were found. The top of the formation was found only by means of the strongly outcropping Risdon Sandstone which directly overlies the top of the Woodbridge, and the total thickness of the latter formation in this section is approximately 300 feet.

The other complete section of the "Woodbridge Glacial Formation" is a road section just south of the town of New Norfolk, commencing at 958313 (Hobart Sheet). This section has practically continuous outcrop from the base of the "Woodbridge Glacial Formation" through to about 100 feet above the base of the Ferntree Formation. The lowest rock is a creamy-white sandstone, coarse-grained and very poorly sorted. Angular quartz fragments up to ⅛-inch long are quite common and the size of the particles making up the matrix grades down to mudstone size. Small amounts of feldspar are present as angular fragments. Spiri-

ferid brachiopods are present in small numbers but no other fossils were seen. The erratics at this level rarely exceed ¼-inch in length and there are only a few as long as this. They are sub-rounded quartz pebbles. The base of the formation is not exposed but it is thought that the lowest exposure is very close to the base, probably within ten feet of it. This basal member is approximately 24 feet thick and is for the most part of the same lithology, although there are some bands which are slightly finer-grained.

The basal member grades up into fine-grained, buff-coloured sandstone, which is moderately well sorted, although there are scattered erratics of smaller dimensions (about ⅛-inch long). The boundary between these two members is gradational, with alternating bands of coarse and fine sandstone, so the thickness of them has been fixed somewhat arbitrarily. The fine-grained member has a fairly constant lithology, but it contains some coarser patches, in which the erratics become slightly larger. The thickness of this member is about 56 feet, but as both the top and the bottom are gradational, this thickness is of necessity, only approximate.

Overlying the fine-grained sandstone member is a thick succession (about 160 feet) of coarse, poorly-sorted sandstone alternating with a fine to medium grained sandstone that becomes fairly well sorted in places. The base of this member has been taken as a three-ft. band of coarse, poorly-sorted sandstone containing dominantly quartz particles 1/16 to ⅛ inch across, set in a matrix of quartz fragments of medium sand size. The matrix also contains small amounts of angular feldspar grains. Erratics are numerous in this member but the number and size varies considerably. Some bands become very coarse-grained, due to an increase in the number of erratics, while other bands, which contain fewer erratics, appear relatively fine-grained and moderately well-sorted. The erratics are mostly quartz and quartzite but there are also a few slate and schist pebbles and rare granite pebbles. There is a wide range of size amongst the erratics, which vary from less than ¼-inch up to small boulders several inches long. Fossils are rare in this member, the only ones found being two specimens of a planispirally coiled gastropod, which may be *Warthia*, right at the top.

The topmost member in the section is a fine-grained, creamy-white sandstone, which is well sorted and contains only rare erratics. This sandstone contains a small number of *Strophalosia* and a few ramose stenoporids.

This section was measured with an Abney hand level, and the thicknesses have been corrected for the 5° W. dip of the beds, which strike at 200°. The total thickness of "Woodbridge Glacial Formation" exposed in this section is 260 feet. This is in good accord with the thickness of 270 feet recorded at Mt. Nassau (Banks and Hale, 1957). The difference is probably due to the fact that this section is not quite complete at the base.

There appears to have been a marked increase in the intensity of glaciation at the beginning of the deposition of this formation, indicated by the large number of erratics it contains near the base. Erratics become fewer and smaller toward the top of the formation, possibly indicating a gradual decrease in the severity of the glacial conditions.

Risdon Sandstone

This formation is a coarse, usually well sorted sandstone about 20 feet thick, which lies immediately above the "Woodbridge Glacial Formation" and below the Ferntree Formation. It is relatively very resistant to erosion and has a strong, positive outcrop. Quartz is the most abundant mineral in its composition, but fairly large amounts of feldspar are also present. The colour varies from brown to buff, due to iron staining, but becomes white in strongly weathered specimens.

The matrix of the rock is composed of coarse sand-size, sub-angular to sub-rounded quartz fragments, with smaller amounts of angular to sub-angular milky-white feldspar fragments. Set in this matrix are variable amounts of quartz pebbles ranging in length from ⅛-inch to three inches and mostly sub-rounded or rounded. These pebbles are mainly an opaque-white quartzite and on weathered surfaces they stand out strongly against the dark matrix. The pebbles are often concentrated in small lenses, especially near the base of the formation. Scattered mica flakes were seen in some specimens. Current bedding was observed at only one locality.

The thickness of the formation has not been determined accurately because of lack of suitable exposure in the area. On the sides of hills, where the Risdon Sandstone often outcrops well, it may be exposed for a thickness of ten feet, but the underlying and overlying beds are in all cases covered with scree material. The best exposure for a measurement of thickness is in a road section behind the Boyer factory at 980341 (Hobart Sheet). Here the top can be found accurately, but the base is indistinct. The thickness in this section is approximately 20 feet.

A thin section has been cut from a specimen which is a coarse, moderately well-sorted sandstone with a red colour, containing coarser, conglomeratic patches with quartz and quartzite pebbles up to an inch long. In the hand specimen the composition appears to be mainly of quartz, with small amounts of feldspar.

In thin section, this rock is seen to be composed almost entirely of angular to sub-angular quartz fragments, ranging in size from about ⅛-mm. long up to about 1 mm. long. The majority of the fragments are in the ½-mm. to ¼-mm. range. About 5% of the rock is composed of angular feldspar fragments, and there are some sub-rounded slate and schist particles up to ½-mm. long. There is no fine-grained matrix, and the grains are held together by a haematitic cement, which imparts a reddish colour to the rock.

The current bedding and the conglomerate lenses in this formation lead to the conclusion that it is a very shallow water, near shore deposit, possibly shoreline in part. However, the scarcity of erratics in the upper part of the underlying "Woodbridge Glacial Formation" is thought to indicate a retreat of glaciation, which would prob-

ably be accompanied by a rise in sea level. It is difficult to reconcile the shallow water aspect of the Risdon Sandstone with this probable rise in sea level and it seems that the only explanation of this problem is to invoke a slight tectonic uplift of the area immediately prior to the deposition of the Risdon Sandstone.

Conditions appear to have been very stable during the deposition of this formation, since the bedding is very thick, and in some exposures the whole sequence is homogeneous, without any bedding break.

Ferntree Formation

In this area the Ferntree Formation is approximately 600 feet thick and occupies a stratigraphic position between the Risdon Sandstone below, and the Triassic System above. The Cygnet Coal Measures do not occur in this area. Lithologically, the formation consists of siltstones and fine-grained sandstones which are composed dominantly of quartz with small, variable amounts of argillaceous material. The colour of the formation is variable, and can be white, light-grey, cream or buff. In the higher beds, the formation has a mottled appearance, with grey and creamy-brown patches, these different coloured patches often being associated with materials of different grain size. The number and size of erratics is also very variable. In the lower beds, small erratics of the order of 1/16 to $\frac{1}{8}$ inch long are numerous, with rare erratics one inch long. In the higher beds the number of erratics increases considerably and, although there are some bands that contain practically no erratic material, other bands contain a considerable amount, with the erratics ranging in size from less than $\frac{1}{8}$-inch up to several inches.

The bedding in the Ferntree Formation is mainly thick, but some bands have a much finer bedding, with some quite shaley bands.

The fauna of this formation is very sparse, and fossils have been found at only three localities. At 980349 (Hobart Sheet) a few moulds of brachiopods have been found, of which one appears to be a "martiniopsid". This locality is the only one where the stratigraphic position of the fossils is known, and here they occur about 350 feet above the base of the Ferntree. At 928329 (Hobart Sheet), a few spiriferids and pelecypods were found as internal and external moulds.

The third locality, where a relatively rich fauna was found is by the water tanks, just to the west of New Norfolk, at 944327 (Hobart Sheet). Most of the fossils were found in the float material from the excavation of the tanks. Several species of brachiopod were found, including one with a very long hingeline. Several pelecypods were also found, including one similar in appearance to *Myonia*. One specimen contains a number of individuals of *Hyolithes*.

The best section through the Ferntree Formation was found in a road section behind the Boyer factory, commencing at 980341 (Hobart Sheet). Here there are about 500 feet of continuous outcrop from the base up, but the top 100 feet are not exposed.

At the base, overlying the Risdon Sandstone, is a pale-grey, fine-grained mudstone, which is white on weathered surfaces, with a thickness of approximateiy 175 feet. This member will be referred to as member "A". The bedding is generally thick, with beds two to three feet thick, but some bands have a slightly shaley bedding. The beds have an uneven fracture roughly parallel to the bedding, which causes the rock to break into large flakes when hit. The rock is composed mainly of quartz particles, and in the hand specimen it appears to be a fine-grained sandstone. Erratics, almost exclusively of quartz, are fairly common, although they rarely exceed 1 mm. in length. There are, however, rare large erratics about two inches long, and also scattered mica flakes in this member. The beds dip 5° S. and strike at 270°. In thin section, it is seen that 15-20% of the rock is composed of angular quartz fragments, 1/16 mm. to $\frac{1}{4}$ mm. long, with some scattered feldspar fragments up to $\frac{1}{4}$ mm. long. There are also a few smaller, silt-size quartz fragments. This material is set in a very fine-grained matrix, whose composition is indeterminate, although it certainly contains considerable amounts of mica, presumably authigenic.

The next member, Member "B", is 85 feet thick and consists of massively-bedded, medium-grained, poorly-sorted sandstone. It is white in colour, and weathers to a pale cream. In the hand specimen, the major part of the rock appears to be material of medium to coarse sand size, with some fragments up to $\frac{1}{2}$-inch long. Quartz and slate are the most common rock types among the erratics, which are very numerous. In thin section the rock is an apparently unorganized jumble of mineral fragments (mostly quartz, but with appreciable amounts of feldspar), and some rock fragments, set in a fine-grained siliceous matrix. The majority of the fragments are of the order of $\frac{1}{4}$-mm. long, but they range in size between 3 mm. and $\frac{1}{8}$-mm. The quartz fragments are very irregular in outline, generally angular and with a low sphericity. The feldspar fragments are generally slightly more regular, having broken along cleavage planes, but these also are angular. Not many rock fragments are present, but those that are have elongated outline, are sub-rounded, and are up to $\frac{1}{2}$-mm. long. They are fine-grained micaceous slate, and the shape of the fragments is apparently strongly controlled by the schistosity planes. The matrix, which comprises about 30% of the rock, consists of silt-sized particles, ranging in size up to the finest sand grade. The majority of these particles are quartz.

Member "C" comprises 20 feet of shaley mudstone. In the hand specimen it appears to be fine grained and moderately well sorted, with very few erratics. The colour of fresh surfaces is cream to grey, but weathered surfaces are brown. Some faint impressions are preserved in this member and it is thought that they may be the remains of plant stems. In thin section, about 60% of the rock is seen to be composed of a fine, fairly even-grained mudstone, dominantly quartzitic, but containing appreciable amounts of mica, which is presumed to be authigenic. The remainder of the rock is made up of very coarse patches, containing

angular fragments ranging from ⅛ mm. to 2 mm. long, although the majority are about ¼ mm. long. There are also a few sub-rounded elongated fragments of a fine micaceous slate or schist. These larger particles are mostly concentrated into small lenses.

Above this member comes 40 feet of greyish mudstone, with a slightly shaley bedding, which has been called Member "D". This member, in the hand specimen, appears to be moderately well sorted, with practically no erratics and seems to contain a moderate amount of argillaceous material. Towards the top it becomes massively bedded, and slightly coarser-grained. The number and size of the erratics also increases, and there are small patches that are slightly iron-stained. A thin section from near the base (Spec. 7594) is a fine-grained, well-sorted mudstone, dominantly siliceous, but containing small amounts of authigenic mica in the matrix. Very few of the fragments are more than ⅛ mm. long and most of them are less than 1/16 mm. long, and are hence in the silt range of size. The fine-grained, indeterminate matrix makes up about 50% of the rock. A thin section from near the top of the member (Spec. 7596) differs mainly in having a greater proportion of coarser material with the matrix comprising only about 30% of the rock.

Member "E", which is about 30 feet thick, is slightly gradational with Member "D". It is a poorly-sorted, fine-grained sandstone, containing numerous erratics of coarse sand size, and some of larger size. The member is massively bedded, with beds three to four feet thick. In parts it is extremely hard and breaks with a conchoidal fracture. The colour is very variable, ranging from grey and buff to pink. A few poor fossils were found in this member fairly close to the base; they are internal moulds and casts of spiriferid brachiopods.

The topmost member in the formation, Member "F", is a medium to coarse grained sandstone, very poorly sorted and varying in colour from a creamy-brown to a medium-grey. It often has a characteristic blotchy appearance, with patches of grey and brown, the different colours being associated with material of different grain size. The bedding is massive and the outcrop is quite strong for the lowermost 50 feet, but the top part of the member does not outcrop, apart from varying amounts of float material. It probably extends through to the base of the Triassic System, which would make the thickness about 150 feet. Near the base of this member, the rock is a medium-grained, very poorly-sorted sandstone, mainly gray in colour. Quartz is dominant in the composition, both in the erratic material and in the matrix, but small amounts of feldspar are present in the matrix, and some of the coarser fragments, which are up to ½-inch long, are slate. Some doubtful organic remains were found near the base of this member (Spec. 7597). A thin section from near the base (Spec. 7597) has about 60% angular quartz fragments ⅛-mm. to ¼-mm. long. There are also a few scattered feldspar fragments. The remainder of the slide is composed of fine-grained (coarser silt sizes) quartzitic matrix, the distribution of which is variable. In some parts of the slide, there is practically no matrix, and the larger particles are packed together so that these areas have the appearance of a well-sorted sandstone. In other parts of the slide, the matrix is dominant, and contains only a few coarse fragments. The rock has been classed as a medium-grained sandstone. Higher in the member, there are cleaner bands, and also some finer-grained bands, but, on the whole, it remains a medium-grained, poorly-sorted sandstone. Mica flakes are quite common at some levels and there are rare larger erratics up to two inches long.

Unfortunately, the topmost 100 feet of the Ferntree never have a strong outcrop in this area and it has not been possible to measure this part of the formation with any accuracy. Scree material lithologically similar to Member "F" of the Boyer section, has been found in several places, but often the upper part of the Ferntree is covered by scree material from the overlying Knocklofty Formation. At 968499 (Brighton Sheet), there is a considerable amount of scree material, consisting of a grey, fine to medium grained blotchy sandstone similar in appearance to Member "F". It appears to be about 160 feet thick, and float material ocurs to within 30 feet of the Triassic. Worm casts are common in this rock.

At 964407 (Brighton Sheet), on the Black Hills road, there is a band about two feet thick, which is a fine-grained mudstone, very poorly sorted, soft, and slightly friable. It contains numerous quartz erratics up to ¼-inch long, which are sub-angular to sub-rounded. This band seems to reflect more strongly glacial conditions than other parts of the upper Ferntree Formation, and probably represents a minor re-advance in glaciation. Its stratigraphic position is approximately 100 feet below the top of the Ferntree. There is practically no outcrop between this band and the Triassic, but just below the base of the Triassic (which does not outcrop—the base has been estimated on the basis of float distribution), there is a band about six feet thick of fine-grained, yellow-brown, friable sandstone. This is thought to be very close to the top of the formation. It contains very rare erratics.

At 914336 (Hobart Sheet), a thin band of coarse, poorly-sorted sandstone outcrops. This is similar to the Risdon Sandstone in its lithology, and its mode of outcrop is also very similar. It can be traced around the side of a hill for about half a mile. A small outcrop of a lithologically similar rock has been seen at 970348 (Hobart Sheet), but here it does not outcrop in a band as in the first-mentioned case. The stratigraphic position of the former outcrop is not known, but it is probably the same as that of the latter outcrop, which occurs about 200 feet below the top of the Ferntree. A thin section from this outcrop shows about 80% of angular to sub-angular quartz and feldspar fragments from ¼-mm. to ½-mm. across, set in a very-fine-grained quartzitic matrix, which contains appreciable amounts of authigenic mica. Most of the coarse fragments are quartz, of which the majority are clear and colourless, but some are cloudy with inclusions; others are strongly shattered, and some have a wavy extinction, indicating that at least part of the material in this rock was

derived from a metamorphic terrain. About a tenth of the coarse fragments are plagioclase, which is usually clear and colourless. Some of the fragments have an almost complete crystal outline. There are a few scattered mica flakes and some sub-rounded slate and schist fragments up to 1 mm. long.

This band appears to have been deposited quickly, without much water transport, as indicated by the large amount of feldspar present and the angular nature of the particles. It is very similar to the Risdon Sandstone in hand specimen, but seems to be less well-sorted. In thin section it differs from the Risdon mainly in the presence of the fine-grained matrix. Similar sandstone bands from the Ferntree have been reported by Fairbridge (1949) and Ford (1956), but the bands described by these authors are less than 150 feet above the base of the formation.

Finally, a note with regard to the name of this formation. Up to the present, the name Ferntree Mudstone has been widely used, but in this area at least, the formation contains considerable amounts of sandstone, and in accord with Section 3, paragraph 14 (*a*), of the Australian Code of Stratigraphic Nomenclature, it is suggested that it be renamed Ferntree Formation.

Triassic System

In the area under discussion, it has been found impractical to divide the Triassic sediments into Knocklofty Sandstone and Shale, and Springs Sandstone, since characters of both these formations are present. These sediments have been mapped as a single unit, which is called here the Knocklofty Formation.

This formation overlies the Ferntree Formation of the Permian System with a probable slight disconformity, evidence for which is inconclusive. Firstly, the presence of basal grits in some localities indicates some break in deposition. Secondly, in Specimen 7572, from 962374 (Brighton Sheet), there are scattered flakes of a soft mudstone, which could be Permian sediment, and, if this is the case, a disconformity is certainly indicated. Thirdly, dips at the base of the Knocklofty Formation appear to be slightly different from those at the top of the Ferntree Formation, although the smallest stratigraphic interval at which measurements have been made is 70 feet.

The basal grit, or granule conglomerate, appears to form a thin, discontinuous band at the base of the Knocklofty Formation, but this never outcrops, and its distribution and thickness must be estimated in all cases from concentrations of boulders. This rock consists mainly of angular to sub-rounded quartz fragments which range from medium sand size up to granules $\frac{1}{8}$-inch across. Feldspar varies from about 5% to 15% of the composition, mainly as angular particles. There is practically no fine-grained matrix, but some specimens are a reddish colour, due to the presence of small quantities of ferruginous cement. Small disc-shaped cavities in the rock probably represent weathered mud pellets.

Apart from the basal granule conglomerate, the lithology of the Knocklofty Formation is exceedingly uniform. It is mainly a medium to coarse-grained sandstone, usually well sorted and consisting almost entirely of sub-angular to rounded quartz fragments. There are very small amounts of feldspar in some specimens and occasional mica flakes have also been seen. Graphite flakes are common near the base. Fine-grained matrix is practically non-existent in most cases.

Interbedded with the sandstone are thin beds of very fissile shale. This is very easily weathered and is seldom seen, solid outcrop having been observed at only two localities. The best of these is at 918348 (Hobart Sheet), in a road cutting on the Lyell Highway, near a water pumping station. Here there are shale beds up to a foot thick and the rock is a fine-grained, well-sorted mudstone, composed dominantly of quartz but also containing considerable amounts of mica, which give it a strong sheen. It is a pale-greenish colour.

Lack of any distinctive marker beds in the Knocklofty Formation makes stratigraphic work on this formation practically impossible. The nearest approach to marker beds are two horizons at which mud pellets and charcoal fragments occur. The mud pellets have been found in several specimens, but all quite close to 935307 (Hobart Sheet). The actual mud pellets have weathered out, leaving a disc-shaped cavity about an inch in diameter and $\frac{1}{4}$-inch thick. The stratigraphic position of these pellets is not known. The charcoal fragments have been seen at only one locality, 912432 (Brighton Sheet), and all the ones seen occurred in a single large boulder; they are all between $\frac{1}{4}$-inch and $\frac{1}{2}$-inch long. The stratigraphic position of these fragments is not known, either, since they occur only a few feet above a sill-like dolerite intrusion. They are probably plant remains that were carbonised at the time of the dolerite intrusion.

The total thickness of the Knocklofty Formation is not known, but it is certainly over 1,000 feet. The formation caps the hill rising behind the Boyer factory, and the thickness exposed here (incomplete) is approximately 1,100 feet. There is also a considerable thickness exposed along the old Black Hills road, where the Knocklofty overlies the Ferntree, and is overlain by dolerite. The thickness of this section, also incomplete, is just over 1,000 feet.

"Feldspathic Sandstone"

One small outcrop of this formation has been found. It is a block about one mile long and a quarter of a mile wide, which is bounded on the north and north-east by the Tertiary Magra Fault, and on the west by a fault of probable Jurassic age. The southern boundary is formed by an approximately concordant dolerite body which overlies the sandstone. This block is completely isolated from other Triassic sediments, but it is assumed to be younger than the Knocklofty Formation, due to its lithological similarities to the "Feldspathic Sandstone", which occur above the Knocklofty Formation in other parts of Tasmania.

The rock consists mainly of sub-rounded to sub-angular quartz fragments of medium to coarse sand size, with about 15-20% of milky-white feldspar

fragments. There is also some dark-greenish black mineral, probably ferromagnesian, which gives the rock an overall greenish tinge. There is very little fine-grained matrix, and the rock is very friable and easily weathered.

Jurassic (?) System

Dolerite

The age of the dolerite is not known, but evidence from other parts of Tasmania suggests that it is probably Jurassic. The form of the intrusions will be discussed under Structural Geology.

The dolerite is mainly a dark-grey, medium-grained rock, composed of pyroxene (augite, pigeonite, and hypersthene), and plagioclase, with minor accessory minerals. The plagioclase laths are commonly zoned from oligoclase at the edge, to labradorite in the centre. Local variations are present in the dolerite, and the most common is the fine-grained, chilled dolerite at the contacts with sediments. Very coarse phases have been seen at a few localities.

Tertiary System

Basalt

There are three separate masses, all close to the town of New Norfolk, and all probably small flows. The smallest body, occupying an area of roughly a quarter of a mile, is centred at 910340 (Hobart Sheet) and overlies the Knocklofty Formation. This basalt borders a small Tertiary fault, and is close to the larger Lawitta Fault, also of Tertiary age.

The second body occurs on the Lyell Highway just east of Millbrook Rise, and has a maximum exposed thickness of 30 feet. This may have originally been part of the large flow which occurs within the town of New Norfolk. The best exposure of the main body is at 956333 (Hobart Sheet) in the banks of the Lachlan River, where it forms cliffs about 30 feet high. The most remarkable feature here is the columnar jointing. The columns, which are of the order of three to six inches across, dip at various angles, and in one place form a syncline-like structure.

In the hand specimen, the basalt is a dense, very-fine-grained rock, containing amygdales often filled with calcite, and nodules of olivine up to an inch across. In thin section it is seen to be an alkali basalt of the basanite group, and contains large amounts of iddingsite. A more detailed investigation of the basalts in the Derwent Valley has been made by McDougall (1959A).

In all cases the basalts occur near the intersection of two Tertiary faults, and some relation, tectonic if not temporal, is indicated. The age of the basalts is not known accurately. They overlie Triassic sediments, and underly river sediments of unknown age. They are apparently later than the Tertiary faulting.

Quaternary System

Pleistocene (?) Series

Extensive gravels and sands occurring along the valley of the Derwent River have been given a Pleistocene age by Lewis and Murray (1935) and Lewis (1945), who have correlated them with different phases of the Pleistocene glaciation. However, this age is not substantiated by any fossil evidence and is open to some doubt. The question of the age of the deposits will be discussed more fully later.

The best outcrops of these deposits are at Millbrook Rise (970329 and 980327, Hobart Sheet), New Norfolk (957336, Hobart Sheet), the new Lachlan Park Hospital (957327, Hobart Sheet), and Boyer (969,337, Hobart Sheet).

At Millbrook Rise the sediment is a gravel which rests on a basalt surface and contains pebbles of a very wide range in size, varying from sand-size particles up to small boulders six inches across. The pebbles and larger blocks are mostly of Permian sediments, and these are mostly angular to sub-rounded, with a low sphericity. There are also numerous dolerite boulders, which are well rounded and have a high sphericity, and some basalt pebbles, mainly sub-angular. Some well-rounded quartz pebbles are presumably second or later cycle material, having weathered from the Permian sediments. This deposit shows rudimentary bedding, with coarser, very pebbly bands alternating with finer bands containing only a few pebbles.

The deposit at Boyer is also mainly gravel, with pebbles almost entirely of Permian sediment. There are no dolerite or basalt pebbles, but there are a few second cycle quartz pebbles weathered from the Permian sediments. The pebbles in this deposit are angular to sub-angular, and do not appear to have been transported for any great distance. They are often tabular or discoid in shape, so that there is a pronounced preferred orientation parallel to the rudimentary bedding. The pebbles in the lower part of this exposure are rarely more than two inches long, but in the higher parts of the exposure they reach a length of six inches quite commonly. The pebbles are set in a matrix of fine sand and silt-size particles, which comprises about 40-50% of the deposit. The whole deposit is quite friable.

There are bands and lenses of the order of two to three inches thick in this deposit, which vary in pebble content. Some of these contain very few pebbles, and others contain very little fine-grained material. Besides these small lenses, there is one very large lens which contains practically no pebbles. This is a fine to medium grained sand, almost entirely quartz, well sorted and moderately lithified, although still quite friable. It is medium brown in colour. In the road cutting, this band is about 20 yards long, and about five feet thick at its thickest part, but a similar lens occurs at a slightly lower level, in a different part of the cutting, and it is possible that the two are continuous. The thickness of the sandy lens is extremely variable, and at one place it changes from five feet to six inches, within a horizontal distance of about two yards and then thickens again to four feet in a similar distance. All the irregularity is at the top of this band, the bottom being quite regular, and almost horizontal. It appears that after the deposition of the sandy layer, strong current action eroded channels in

it, and that these channels were later filled with coarse gravel. This suggests that the deposits are fluviatile rather than lacustrine.

In the road cutting at New Norfolk, the deposits are a medium to coarse sand, and have some signs of bedding. In the excavations for the new Lachlan Park hospital, the deposit is similar, although it cannot be seen whether or not this deposit is bedded. The average grain size of the sand here varies slightly between outcrops, and in some it becomes quite coarse, composed dominantly of sub-rounded to rounded quartz fragments. In some parts the average grain size is rather small, with a considerable amount (40-50%) of argillaceous matrix, and sub-rounded quartz fragments. Small plant stems, about $\frac{1}{4}$-inch in diameter and an inch long, were found in an upright position in one of the finer patches, and portion of a silicified tree trunk, about three feet long and a foot thick was found in a horiznotal position in one of the coarser patches.

The extent of the river sediments it difficult to determine, since, towards the margins of the valley, they are covered by scree from the hills, and the extent in the direction of the river is also obscured by younger deposits. The most extensive area of the deposits is in the region immediately to the east of New Norfolk, where they have a north-south extent of about 1,500 yards as they run up into the valley of the Lachlan River, and an east-west extent of nearly 4,000 yards, decreasing to a thin band along the present river banks.

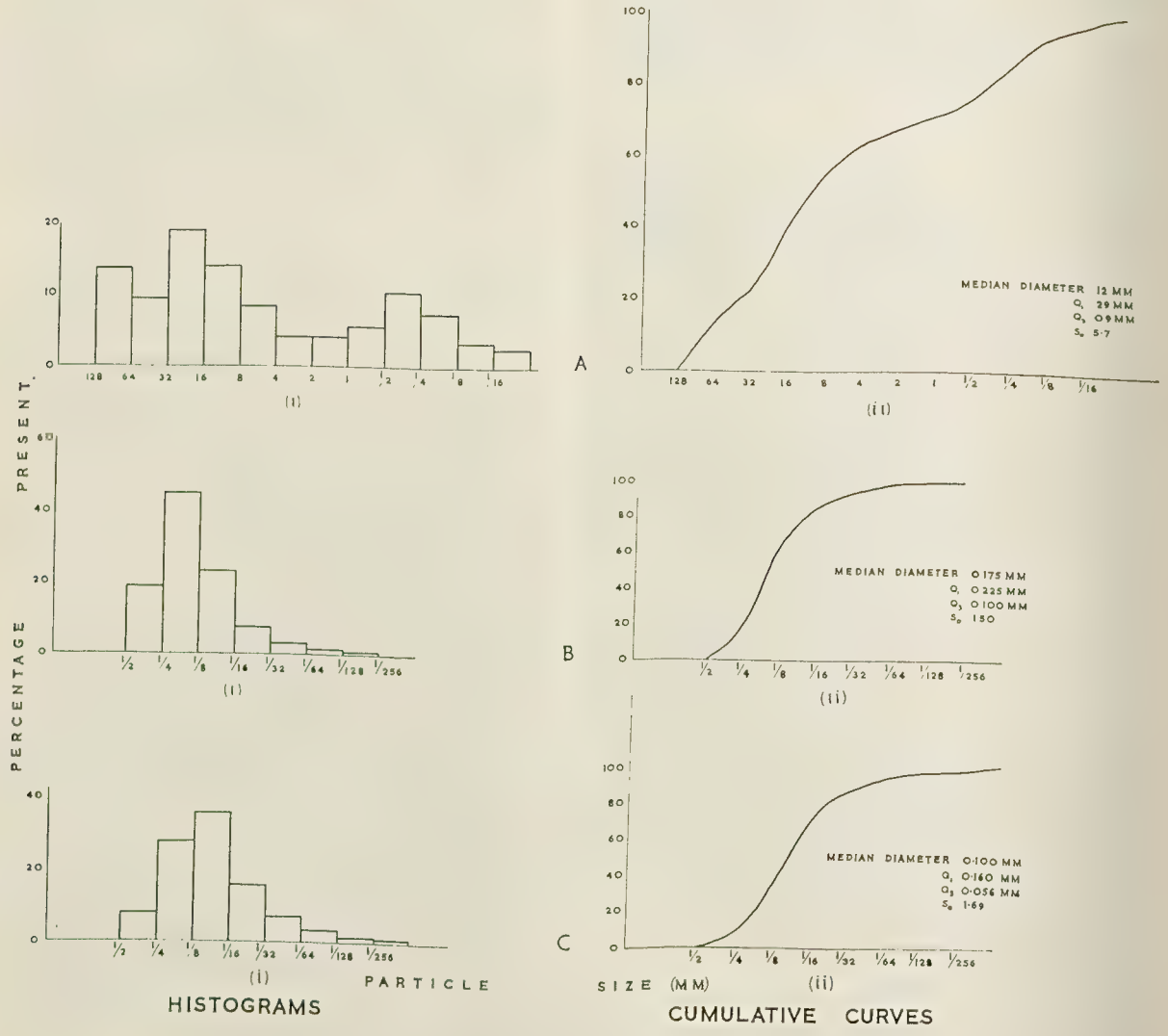

FIG. 1

The deposits are also quite extensive on the north side of the river, to the west of Boyer, where the east-west extent is 2,000 yards, with a maximum width of 1,000 yards.

Three mechanical analyses were carried out on these sediments. One sample of the gravel, from the exposure half a mile east of Millbrook Rise (977328, Hobart Sheet), was analysed and two sand specimens, from:—

(*a*) approximately one mile west of Boyer, in the road cutting where the road passes under the railway line, at 969337 (Hobart Sheet). The specimen was taken from near the base of a sand lens about four feet thick;

(*b*) the road cutting just outside the town of New Norfolk, on the Hobart side, at 956336 (Hobart Sheet).

These results are shown graphically as histograms and cumulative curves in the accompanying diagrams (Fig. 1). Consider first the histogram of the gravel specimen (Fig. 1A). There are a large number of grades represented, showing that the sediment is poorly sorted. The histogram has a bimodal aspect, with high concentrations in the -32 $+16$ mm. and $-\frac{1}{2}$ $+\frac{1}{4}$ mm. ranges. These features of poor sorting and bimodality are characteristic of fluviatile conglomerate deposits (Pettijohn, 1949).

The histograms and cumulative curves for both the sand specimens are similar in appearance, with a high concentration in the finer sand sizes and a gradual decrease down through silt sizes. Neither specimen has appreciable amounts of very fine-grained material; the New Norfolk specimen (Fig. 1B) has only a negligible amount finer than 1/256 mm., and the Boyer specimen (Fig. 1C) has only 1% less than 1/256 mm. The main difference between the two sands is that the Boyer specimen is slightly finer. This is shown mainly by the different position of the mode, which, in the Boyer specimen, falls in the $-1/8+1/16$ mm. grade. The finer character of the Boyer sand is also shown by the smaller amount of material in the $-\frac{1}{2}+\frac{1}{4}$ mm. and $-\frac{1}{4}+\frac{1}{8}$ mm. grades and the relatively larger amount of material in the silt grades. The degree of difference is shown by the median diameters (see Fig. 1).

By the nature of the field occurrence, with channel cut-and-fill structure, it is thought that the Boyer sand is a fluviatile deposit, and from the very similar nature of the mechanical analyses of the two sand specimens, it is thought that the New Norfolk specimen is also a fluviatile rather than a lacustrine deposit. The large number of grades represented in these sands also suggests a fluviatile origin, since Pettijohn (1949) states that fluvial sands normally have six or seven grades present.

The age of the river sediments has already been mentioned as being Pleistocene, according to Lewis, who states that they are younger than the basalt. He correlates them with different phases of the Pleistocene glaciation in Tasmania. From the field evidence, they certainly do appear to be younger than the basalt, and it is quite certain that some of them, at least, are post-basaltic, since gravels can be seen to lie directly on basalt in the exposure just east of Millbrook Rise. At the site of the new buildings of the Lachlan Park Hospital, outcrop of the river sediments has been found within about 100 yards of the basalt outcrop, and at a height of 30 feet above the basalt. On the other hand, however, the river sediments exposed in the road cutting on the Lyell Highway just outside New Norfolk (957336 Hobart Sheet) are at a lower level than the basalt, although no basalt can be seen to directly overlie the sediments.

Recent Series

River deposits assigned to this age are of limited extent along the banks of the Derwent and some of its tributaries, notably the Lachlan River. They occur at levels of less than five feet above the river's summer level, and are presumably flood gravels. There are also fairly extensive mud flats along the river to the east of New Norfolk. Dolerite boulders are very common in the gravels. The areal extent of these deposits has been determined mainly from aerial photographs, on which they show as much darker areas than the older, Pleistocene (?) river sediments.

STRUCTURAL GEOLOGY

The structure of the area is dominated by the intrusions of dolerite, which are probably of Jurassic age. The forms of the intrusions are quite variable, and, although the dolerite bodies taken as a whole are approximately sill-like, truly concordant contacts are not common. In general, the contacts seem to vary from roughly concordant to strongly transgressive and some vertical contacts have been seen. The sediments along intrusive contacts are often strongly baked, the baked material usually occurring as float. These contacts are commonly obscured to some extent by dolerite scree.

The other main feature of the structure of the area is the fairly extensive post-dolerite faulting, which is presumably of Tertiary age. Most of these faults trend in a south-easterly direction, cutting across the south-west corner of the area. Most of them are small, having a throw of only two or three hundred feet, although there is one much larger one (Glen Fern Fault), which has a throw of over 1,000 feet. They are vertical or near vertical faults and seem to have been formed under tensional conditions.

The major portion of the dolerite appears to be a single body, extending over most of the Black Hills square, and coming south into the northern parts of the New Norfolk square, with the lowest part running south to the Derwent, along the western edge of the area. The base of this mass has a contact varying from nearly concordant to very strongly transgressive, and its stratigraphic position varies from high in the Ferntree Formation, to over 1,000 feet above the base of the Knocklofty Formation. The base of this mass is approximately concordant where it intrudes the Ferntree Formation, at a height of about 700 feet above sea level, in the northern part of the New Norfolk square. From here the base rises with a strongly discordant contact into the Knocklofty

Formation, with the contact trending in a northerly direction.

The height of the base is raised by approximately 700 feet by the Tertiary Magra and Black Hills Faults, and then, becoming approximately concordant, it runs along the valley of the Back River. It swings around the head of the valley, and then trends along the side of the ridge leading to Mt. Dromedary. It continues along this ridge in a series of concordant and discordant stages and finally swings around the southern side of the mountain, becoming strongly discordant, and getting lower in stratigraphic height, till just to the east of the eastern boundary the base of the dolerite is only slightly above the base of the Triassic.

The base of the dolerite probably attains its greatest height, both topographically and stratigraphically, a short distance to the north of the head of the Back River valley. Where the base is exposed at the extreme northern boundary of the Black Hills square, the height has dropped by about 400 feet and its position in the sequence has dropped to about 600 feet above the base of the Triassic. To the north-west, the base decreases in height from the head of the Back River valley, where the maximum exposed height is just over 2,000 feet (about 1,000 feet above the base of the Triassic), to about 1,300 feet at the northern end of a small exposure terminated at the south by the Tertiary Black Hills Fault (912442, Brighton Sheet). The base of the dolerite here rises to the south, and is almost 1,700 feet against the fault, the contact here appearing to be slightly discordant.

Further south, there is a small block of "Feldspathic Sandstone", whose northern boundary is the Magra Fault. Both these faults have their southern side downthrown, with a total throw of 600-700 feet. The base of the dolerite on either side of the faults is now approximately the same, so it would seem that there was a rise in the base of the dolerite of about 600 feet between these two blocks before the Tertiary faulting. One explanation is that there was Jurassic movement along the line of the Magra Fault, with the southern side upthrown. The later Tertiary movement was then in the opposite sense.

To the south of these two faults, the base of the dolerite falls in a series of concordant and discordant contacts, down to river level in the bed of the Derwent. The southern limit of the dolerite is not known, since along the valley of the Derwent it is covered by younger river gravels. It can be placed with some degree of accuracy at one locality only, namely in the banks of the river where it crosses the western boundary of the area. Here there is a small outcrop of Triassic sandstone on the south bank of the river and dolerite outcrops in cliffs in the north bank. Just to the west of this locality the contact is shown fairly closely, and seems to be strongly discordant. In this part of the area the base of the dolerite falls very low in height, but stratigraphically it remains high in the Knocklofty Formation.

Along the eastern half of the extreme northern boundary of the Black Hills square, the base of the dolerite is approximately sill-like, but for the most part the contact runs just north of the boundary and only cuts into this area for a short distance. The dolerite is intruded into the Knocklofty Formation at a considerable, but not accurately-known, height above the base.

Another dolerite mass, not as extensive in outcrop as the one just described, occurs in the south-east part of the New Norfolk square. This mass is intruded into the Grange Mudstone and the top, which is the only part exposed, seems to be approximately concordant, with the top about 100 feet below the upper limits of the formation. There are some irregularities in this contact, however, and at one place the dolerite rises right to the top of the Grange. This lower body appears to be connected to the higher one in the Triassic sediments by a dolerite mass in the central southern part of the New Norfolk square. On the east and west this mass is bounded by almost vertical contacts, and the dolerite rises from a horizon about 100 feet below the top of the Grange Mudstone, up to a level high in the Ferntree Formation. Further south, it probably rises right into the Triassic.

The south-eastern corner of the New Norfolk square seems to have been lifted by the lower dolerite mass, and to the south of the town, Grange Mudstone has been lifted to a level equal to that of the middle parts of the Ferntree. This means an uplift of about 400 feet or more and some tilting was probably involved, since other parts of this block do not seem to have been raised by an equal amount. The northern extremity of this block is marked by a fault of Jurassic age, which is revealed as a vertical dolerite contact, associated with baked sediments, which cuts off the northern end of the two dolerite inliers exposed in the two creeks to the east of New Norfolk. These two contacts were probably part of the Jurassic fault, but the two parts have been offset by the Tertiary Boyer Fault. There is some possibility that the Boyer Fault had some transcurrent movement, since the two parts of the Jurassic fault have been offset by a considerable distance, although the dolerite contacts appear to be vertical.

The Tertiary faults of the area form a system of south-easterly trending faults, with some shorter ones running approximately north-south and north-north-east. The largest of these is the Glen Fern Fault, which cuts across the extreme south-west corner of the area, throwing Berriedale Limestone against Knocklofty Formation and hence having a throw of nearly 1,200 feet. This fault, which has the north side downthrown, continues into the square to the immediate west of this one, and it is connected to the Lawitta Fault running about east-west along the Derwent Valley, by a small fault striking about north-north-east. The Lawitta Fault is exposed in the cliffs in the north bank of the Derwent at the Lawitta railway station, where the Ferntree Formation can be seen to be thrown against the Knocklofty Formation. The exact throw is not known, due to lack of complete knowledge of the stratigraphy of these two formations, but it his been estimated at between three and four hundred feet. This fault is not exposed at any other locality and the remainder of its length in this area is covered by river sediments.

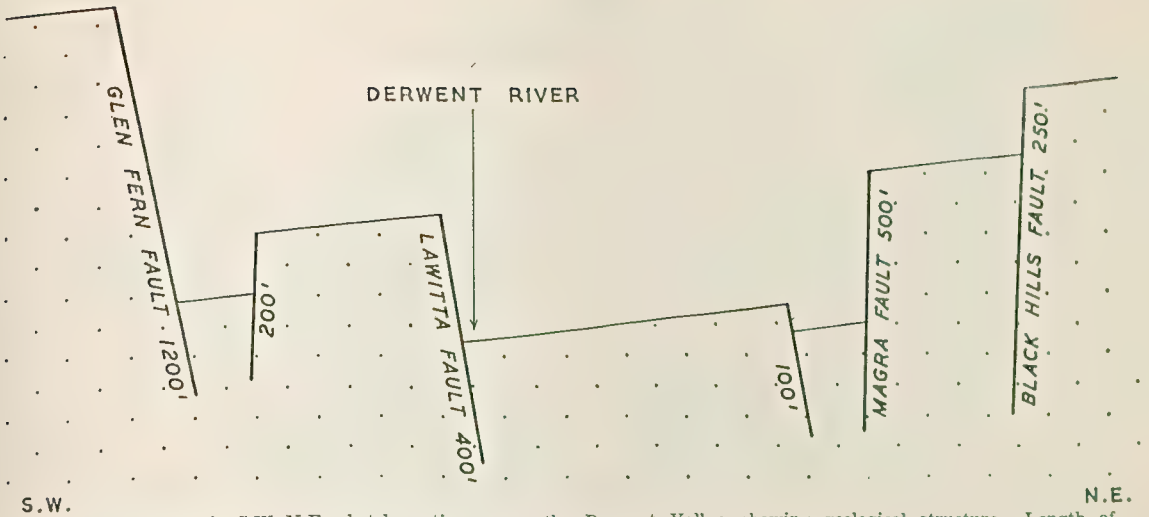

FIG. 2.—Diagramatic S.W.-N.E. sketch section across the Derwent Valley, showing geological structure. Length of section, about five miles.

Hence the exact location of the fault is impossible to find, but certain restrictions on its position make a fairly accurate estimate possible. It is thought that the fault continues from Lawitta to the centre of the town of New Norfolk, and on to Millbrook Rise, where it probably changes to a due easterly direction. The eastern continuance of this fault is open to some doubt, however, since there is very little displacement of beds across the river, although there is some change in dips.

Two other important faults are the Magra Fault and the Black Hills Fault. The throw of the former cannot be estimated accurately, since it throws Triassic against Ferntree, but 500 feet is thought to be a conservative figure, with the south side downthrown. The Black Hills Fault can be seen to have a throw of approximately 250 feet at several places where is displaces the base of the Triassic, and this fault also has the south side downthrown. Thus the Tertiary faults of the area form a wide downthrown block, bounded on the south by the Glen Fern Fault, and on the north, by the Magra and Black Hills Faults, Two other smaller faults complicate the picture slightly, so that the overall picture is one of a series of grabens, horsts, and step faults, as shown in Fig. 2 (not to scale). This down-faulted block runs in a south-easterly direction to the west of New Norfolk and it appears to have had a strong effect on the course of the River Derwent, which flows along the depressed area of the block. At New Norfolk, the Derwent changes to an easterly direction, and appears to flow out of the down-faulted block. The reason for this is not clear, but the extrusion of the basalt at New Norfolk probably diverted the river to the north, and this possibly caused the river to take up its new direction.

One important aspect of the structure of the area which has not yet been mentioned, is the large Tertiary fault, with a throw of nearly 2,000 feet (north side down), which has been projected into the Black Hills square from the Dromedary square, where it has been mapped for a considerable distance by McDougall (1959). This fault presumably enters the Black Hills square in a north-westerly direction, but it cannot be traced on the ground because just before it leaves the Dromedary square it enters a region in which there is dolerite on both sides. There is, however, a linear on the aerial photographs, which probably represents the continuation of this fault, and it is this which has been plotted on the map. This fault is probably offset to the north by the fault striking north-north-east across the northern boundary of the square. The only limit on the throw of this fault is that it is less than the thickness of the Knocklofty with the east side downthrown. Thus, it is probably well over 1,000 feet and it is possible that this fault takes up the whole of the throw of the north-west striking fault, although it is more likely that the throw is in part taken up by some smaller faults which, being entirely in dolerite, cannot be found.

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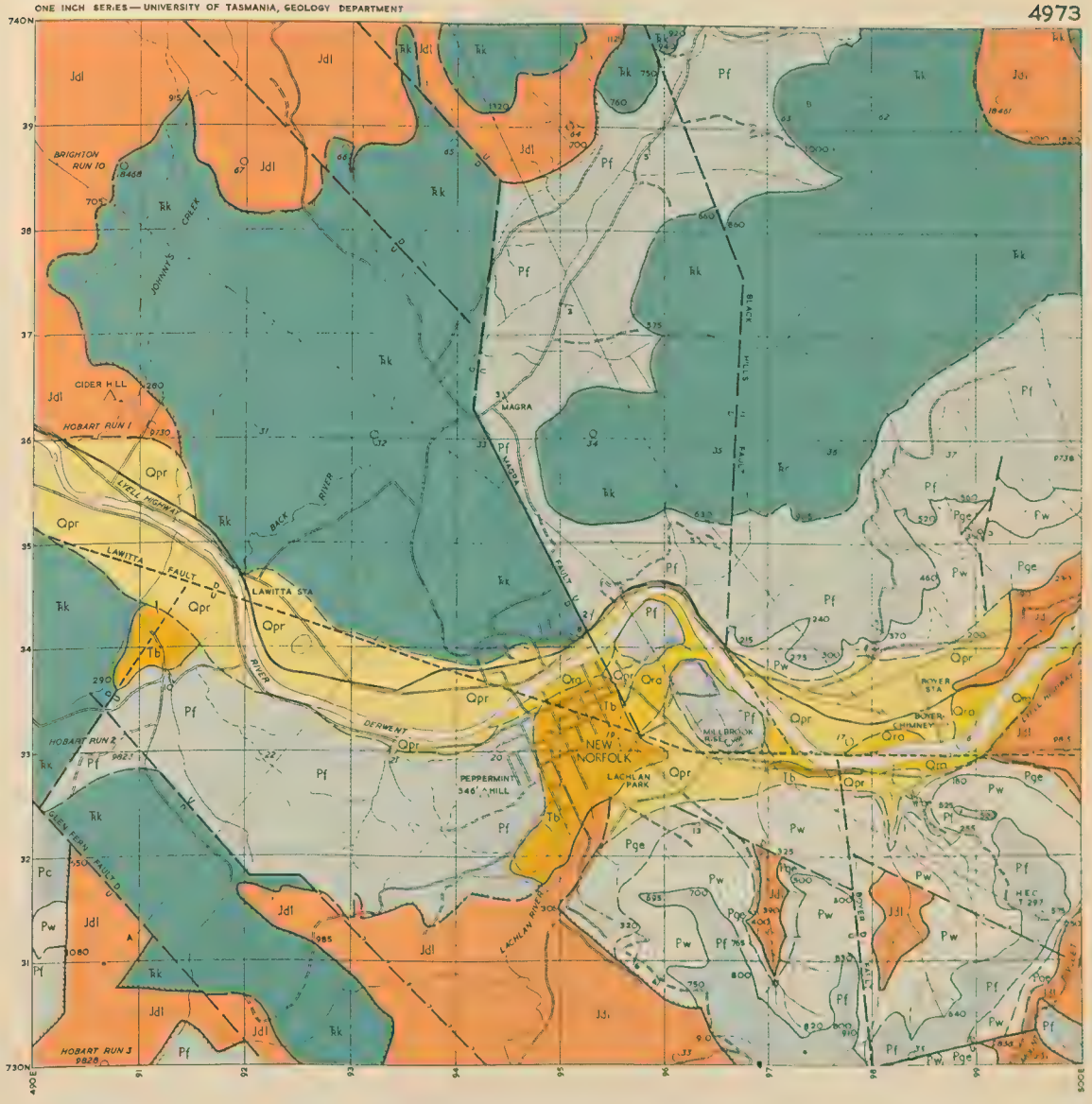
GEOLOGY OF TASMANIA

NEW NORFOLK

ONE INCH SERIES — UNIVERSITY OF TASMANIA, GEOLOGY DEPARTMENT

4973



LEGEND

- FAULT CONCEALED
- FAULT WITH DOWNTHROWN SIDE INDICATED
- FAULT — POSITION APPROXIMATE
- FAULT INFERRED
- FORMATION BOUNDARY
- FORMATION BOUNDARY — POSITION APPROXIMATE

Dolerite Boundaries
- CONCORDANT SILL
- DISCORDANT INTRUSIVE BOUNDARY

- STRIKE AND DIP OF STRATA
- ROAD
- VEHICULAR TRACK
- FOOT TRACK
- RAILWAY LINE
- TRANSMISSION LINE

NUMBERS ON FORMATION BOUNDARIES ARE TOPOGRAPHIC HEIGHTS

Quaternary System

RECENT SERIES
- Qra — ALLUVIUM

PLEISTOCENE? SERIES
- Qpr — RIVER SEDIMENTS

Triassic System
- Tk — KNOCKLOFTY FORMATION

Permian System
- Pf — PERNTREE FORMATION
- Pw — WOODBRIDGE GLACIAL FORMATION
- Pge — GRANGE MUDSTONE
- Pc — BERRIEDALE LIMESTONE

} CASCADES GROUP

IGNEOUS ROCKS

Tertiary System
- Tb — BASALT

Jurassic ? System
- Jdl — DOLERITE

MAPPED AND COMPILED BY D WOOLLEY 1956

Compilation from Aerial Photographs. Trigonometric Station Control by courtesy of the Department of Lands and Surveys Hobart, and the Australian Army Survey Service. Origin of co-ordinates 400 000 yds West and 1 800 000 yds South of True Origin of Zone 7 of the International Grid

— SCALE —

0 1 2 3 4 5000 10,000 FEET

0 1 2 MILES

KEY MAP SHOWING MAGNETIC DECLINATIONS 1957
SECULAR VARIATION 7 MINS P A

GEOLOGY OF NEW NORFOLK
SHEET 4973

PHYSIOGRAPHY

Drainage is dominated by the Derwent River which has eroded a wide flat valley, with extensive fluviatile deposits in some places. Tertiary faulting has exerted some structural control on the course of the river. To the north and south, the country rises to high hills, which have been eroded from sill-like dolerite bodies by streams having steep gradients, and which are still in the mountain tract.

STRATIGRAPHY

Age	Formation	Lithology	Thickness (in feet)
Recent		River deposits	?
Pleistocene		River sediments (sand and gravel)	?
Tertiary		Basalt flows	30+
		Erosion Interval	
Triassic	Knocklofty Sandstone and Shale	Basal fine conglomerate. Sandstone.	1000+
		Disconformity ?	
Permian	Ferntree Mudstone	Siltstone and sandstone.	600
	Risdon Sandstone	Sandstone	20+
	"Woodbridge Glacial" Formation	Sandstone and siltstone	260
	Grange Mudstone	Mudstone	100 approx.
	Berriedale Limestone	Foetid grey limestone, sometimes sandy	?

STRUCTURE

The main structural feature in this area is the system of Tertiary faults, most of which have a south-easterly trend, down the valley of the Derwent. Most of these have a throw of a few hundred feet, but one (Glen Fern Fault), has a throw of 1,200 feet. The dolerite intrusions are generally sill-like, but the contacts are often transgressive.

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GEOLOGY OF TASMANIA

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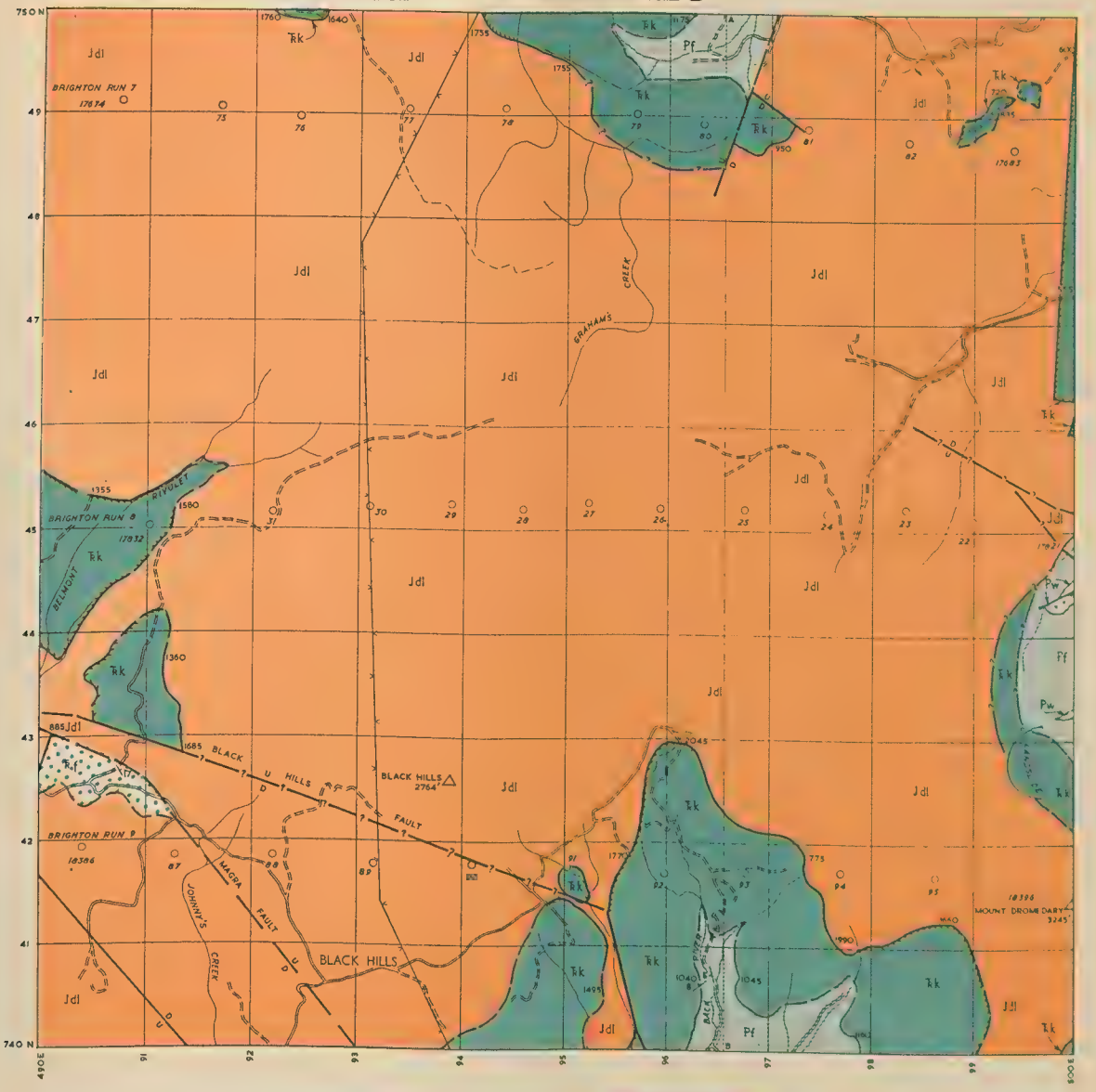
BLACK HILLS

4974



LEGEND

- FAULT WITH DOWNTHROWN SIDE INDICATED
- FAULT — POSITION APPROXIMATE
- FAULT INFERRED
- FORMATION BOUNDARY
- FORMATION BOUNDARY — POSITION APPROX.

Dolerite Boundaries

- CONCORDANT SILL
- DISCORDANT INTRUSIVE BOUNDARY
- STRIKE AND DIP OF STRATA
- ROADS
- VEHICULAR TRACK
- TRACK
- TRANSMISSION LINE

NUMBERS ON BOUNDARIES INDICATE TOPOGRAPHIC HEIGHTS

Triassic System

- Tf FELDSPATHIC SANDSTONE
- Tk KNOCKLOFTY FORMATION

Permian System

- Pf FERNTREE FORMATION
- Pw WOODBRIDGE GLACIAL FORMATION

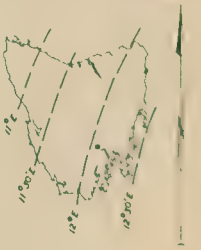
IGNEOUS ROCKS

Jurassic (?) System

- Jdl DOLERITE

Compilation from Aerial Photographs. Trigonometric Station Control by courtesy of the Department of Lands and Surveys, Hobart, and the Australian Army Survey Service Origin of co-ordinates 400,000 yds. West and 1,800,000 yds. South of True Origin of Zone 7 of the International Grid

KEY MAP SHOWING MAGNETIC DECLINATIONS SECULAR VARIATION 7 MINS. PER ANNUM



MAPPED AND COMPILED BY D.WOOLLEY 1956

SCALE

0 1 2 3 4 5000 1 0 2 MILES 10000 FEET

GEOLOGY OF THE BLACK HILLS AREA

SHEET 4974

PHYSIOGRAPHY

The main part of the area is covered by a high dolerite plateau, which is being dissected by streams in the mountain tract. The main drainage is to the south into the Derwent River, but some streams flow north into the Jordan River.

STRATIGRAPHY

System	Formation	Lithology	Thickness (in feet)
Triassic	"Feldspathic Sandstone"	Sandstone with feldspar and ferromagnesians	?
	Knocklofty Sandstone and Shale	Basal fine conglomerates Sandstone	1000'+
		? Disconformity	
Permian	Ferntree Mudstone	Siltstones and sandstones.	600

STRUCTURE

There are a few small Tertiary faults in this area, most being on the noithern fringe of the faults running down the Derwent Valley to the south. Most of the area is occupied by a dolerite body whose base varies from high in the Ferntree Formation to high in the Knocklofty Formation. The top of this body is not exposed.

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PRELIMINARY NOTES ON NOTECHIS SCUTATUS NIGER KINGHORN, ON CAT ISLAND, FURNEAUX GROUP, TASMANIA

By

Terence Cashion

Tasmanian Museum, Hobart

ABSTRACT

The occurrence of *Notechis scutatus niger* on Cat Island is recorded and its feeding habits and comparisons with the common mainland species discussed.

Details of examinations of fifteen specimens of *Notechis scutatus niger* collected on the island are given.

INTRODUCTION

The following observations are based on a stay of some nine weeks on Cat Island between January 14th and March 18th, 1957.

Cat Island is well known for its gannet colony, and my wife and I, on behalf of the Tasmanian Animals and Birds Protection Board, visited the island to protect the gannets during their breeding period.

The stay gave us good opportunity to observe and compile notes on other aspects of the island's fauna.

The present paper is on the occurrence of *Notechis scutatus niger* on Cat Island. (For an account of the bird life of the island see Cashion, *The Emu*, Vol. 58, p. 327.)

THE ISLAND

Cat Island (lat 39° 57′ S., long. 148° 21′ E.) lies three or four miles off the exposed east coast of Flinders Island in Bass Strait. It is flanked by two closely adjacent islands; the much larger Babel Island off the west shore, and the slightly smaller Storehouse Island off the south-east shore.

Cat Island, generally, is low lying, irregular in shape, and is approximately a mile long and nearly as broad at its widest point.

The shoreline is almost entirely rocky, the east shore particularly so. There are two small sandy beaches of about equal size, one on the south side of the island, and the other opposite on the north shore. The island is honeycombed with shearwater and penguin burrows and for the main part is covered with tall dense tussocky grass (*Poa*). Other plant species occur as well. A creeping native spinach (*Tetragonia*) is particularly concentrated near the hut, which is located in a slight hollow between the two beaches. Low shrub and thickets flourish, particularly on and about the slopes of a low sandy knoll just east of the hut. Pigface (*Disphyma*) is also found in profusion, noticeably more so along the western shore.

OBSERVATIONS

Notechis scutatus niger is very common on Cat Island. Originally described from Kangaroo Island and commonly known as the Black Island Tiger Snake, this variety is generally accepted as a melanistic form of the mainland species. The predominant colour is black, but several specimens of olive-brown colouration were met with which showed faint traces of transverse banding. Some authorities suggest that this insular form is lethargic as compared with the mainland species. I did not always find this so. On a number of occasions disturbed individuals made off into the tussocks or down burrows with an agility and speed very comparable with tiger snakes I have observed on the Tasmanian mainland.

If *Notechis scutatus niger* does at times show a tendency towards torpidity it could be influenced by either one of two factors or a combination of both. An overindulgent food supply could induce torpidity as could bleak weather conditions which often prevail in their island homes.

Compared with the common tiger snake, the island variety is also regarded as averaging greater size, individuals exceeding six feet in length having been recorded. This would indicate an abundant food supply as it is certain size and rate of growth in snakes is influenced greatly by the amount of food available. On Cat Island it would seem there is a definite food cycle which would fluctuate, and, due to the availability of young birds, would reach its peak at or about the time of my visit.

It would make an interesting study to follow this food cycle as it would then be possible to obtain a more complete picture of the diet of the snakes at the various stages of the cycle, but such an analysis would, of course, entail an examination of a large number of stomach contents.

A cursory examination of stomach contents of *Notechis scutatus niger* on Cat Island would suggest a tendency for the larger individuals to feed principally on the small young of the Short-tailed Shearwater (*Puffinus tenuirostris*) when these were available, whilst the smaller specimens would concentrate more generally on small skink lizards (*Leiolapisma*) which are very plentiful on the island.

It would appear therefore, that there would be an element of competition in these island snakes, in as much as the more mature individuals would compete with those less well developed for smaller prey, prior to and following the breeding period of the Shearwaters.

The tiger snake, it is said, is largely nocturnal and this it would seem may be true as on three occasions *Notechis scutatus niger* was observed after nightfall close by the hut.

It seems certain they are most active during cooler conditions, especially before and after a rainstorm. On one occasion under such circumstances five snakes were encountered within a few minutes in a small area near the hut. Throughout hot spells their absence was most noticeable, apparently preferring the relative coolness of a burrow or the shade of the dense tussocks.

The following notes are details of examinations of fifteen specimens of *Notechis scutatus niger* collected on Cat Island.

14.1.1957:—
Length: 785 millimetres.
Weight: 90 grams.
Colour: Dark-brown; faint traverse bands. (No other data recorded.)

25.1.1957:—
Length: 847 millimetres.
Weight: 120 grams.
Colour: Blackish-brown. (No other data recorded.)

28.1.1957:—
Length: 720 millimetres .
Weight: 80 grams.
Colour: Black.
Stomach contents: One small skink (*Leiolapisma*) and two tails of the same genus.

31.1.1957:—
Length: 810 millimetres.
Weight: 115 grams.
Colour: Brownish-olive above; throat and underparts anteriorily yellow, graduating greenish-slate towards tail. ♀ ovaries not enlarged.
Stomach contents: Unidentified larvae and fragment of small dark feather.

31.1.1957:—
Length. 770 millimetres.
Weight: 110 grams.
Colour: Blackish-brown, underparts bluish; throat yellowish-white.
Stomach contents: One small skink (*Leiolapisma*) and portion of one of the same genus.

31.1.1957:—
Length: 925 millimetres.
Weight: 150 grams.
Colour: Brownish-olive, faintly banded; underparts bluish; throat yellow.
Stomach contents: Nil.

31.1.1957:—
Length: 995 millimetres.
Weight: 260 grams.
Colour: Black; underparts, throat bluish-white, darkening posteriorly. ♀ ovaries not enlarged.
Stomach contents: Partly digested remains of a young Short-tailed Shearwater.

31.1.1957:—
Length: 1,115 millimetres.
Weight: 470 grams.
Colour: Black; throat bluish-white, darkening posteriorily. ♀ twelve young (approximately 50 millimetres in length) in bifurcate uterus.
Stomach contents: Nil.

1.2.1957:—
Length: 1,000 millimetres.
Weight: 385 grams.
Colour: Olive-brown, faintly indicated traverse bands yellowish-brown; underparts, throat pale-yellow, darkening towards tail. ♀ thirteen young (averaging 150-160 millimetres in length) in bifurcate uterus. The young, brownish-black in colour, were traversely banded.
Stomach contents: Two legs of a very young Shearwater.

1.2.1957:—
Length: 1,285 millimetres.
Weight: 575 grams.
Colour: Black; underparts dark-slate; throat yellowish-white. ♂ ?
Stomach contents: Partly digested remains of a young Shearwater.

7.2.1957:—
Length: 1,125 millimetres.
Weight: 420 grams.
Colour: Brownish-olive, faintly banded yellowish-brown; underparts greenish-slate darkening towards tail; throat yellow. ♂ testes not enlarged.
Stomach contents: Nil.

15.2.1957:—
Length: 1, 125 millimetres.
Weight: 660 grams.
Colour: Black; underparts dark-slate; throat yellow. ♀ thirteen young (approximately 190 millimetres in length) in bifurcate uterus. The young were dark-coloured and traversely banded.
Stomach contents: Nil.

4.3.1957:—
Length: 785 millimetres.
Weight: 110 grams.
Colour: Dark-brown; underparts dark-slate; throat yellow.
Stomach contents: One small skink.

10.3.1957:—
Length. 1,240 millimetres.
Weight: 592 grams.
Colour: Black; underparts dark-slate; throat yellowish. ♂.
Stomach contents: Nil.

16.3.1957:—
Length: 1.095 millimetres.
Weight: 440 grams.
Colour: Dark-brown, faintly banded yellowish-brown; underparts slate; throat yellowish-green. ♂.
Stomach contents: Portion of a very young Blue-tongued Lizard (*Tiliqua*).

Acknowledgements.

My thanks are due to Dr. W. Bryden who read the script and made helpful suggestions; also the Tasmanian Animals and Birds Protection Board for their co-operation and for offering me the opportunity to visit Cat Island, and the Trustees of the Tasmanian Museum for their kindness in granting me leave of absence for my period of stay.

RE-EXAMINATION OF THE FJORD THEORY OF PORT DAVEY, TASMANIA

By

W. E. Baker and Naseer Ahmad

(With 4 Text Figures)

Port Davey, a large drowned inlet in the extreme south-west of Tasmania, has been considered by Lewis (1924, 1928 and 1945) to be a fjord, the result of Pleistocene glaciation to below sea-level followed by post-glacial drowning. As such it has been cited as the only example of a fjord in Australia, and has been widely quoted not only in Australia but in international reviews (e.g., Flint, 1947; David, 1950; Valentin, 1954; Charlesworth, 1957). Nye, (1930) on the other hand, had described Port Davey at a drowned river estuary.

In the course of recent work for the Mines Department of Tasmania during which we spent six weeks together in the area, the authors were afforded the opportunity of examining the region around Port Davey in some detail. One of us (W.E.B.) had previously spent several weeks in the area. As a result of these studies we support the view of Nye (1930).

The statement by Lewis (1945) is as follows: "The most impressive feature of the Malanna glaciation is Port Davey, a glacial fjord, the only one in the Australian region—not in the same category as the fjords of Norway or New Zealand, but, nevertheless, a true example, with white cliffs rising to sharp tinds some 3,200 feet above the deep sinuous channels."

The authors have found no evidence of glaciation at sea level around the shoreline of Port Davey. Not one example of a polished, faceted or striated pebble was found amongst the large number of superficial boulder deposits exposed around the shoreline, nor have any striated or plucked rock surfaces been found, nor any other forms characteristic of ice sculpture. Stereoscopic examination of aerial photographs of the region reveals no sign of glaciation near Port Davey. Clear examples of glacial erosion and deposition are evident in the Norold Mountains although the position of the terminal moraines shows that the limit of glaciation was some 15 miles to the north-east of Bathurst Harbour.

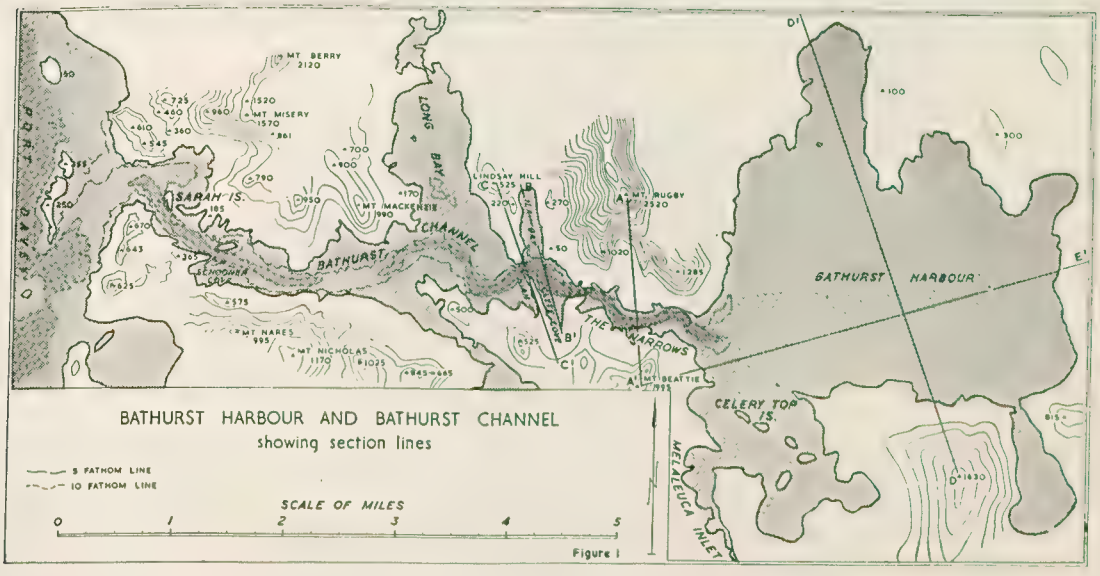

Figure 1

Bathurst Channel, the alleged fjord, has none of the attributes of a glacial valley. There are no truncated spurs. There are no paralliel walls dropping steeply to a flat floor, no valley shoulders. The plan has numerous jagged promontories and inlets, quite typical of that of a drowned river valley, and unlike that of a fjord. Whilst a glacial valley may retain a sinuous course during its development, the highly sinuous nature of Bathurst Channel, particularly through the relatively soft rocks of Long Bay (Figure 1), would not have persisted under the conditions of glacial erosion. Anguiar projections such as Eve Point and Joan Point would have been truncated. The cross section of the valley, whether taken between opposing mountains (Figure 2, Section A-A) or opposed inlets (Figure 2, Section C-C) reveals the normal " V " shape of the river valley. Tributary valleys join at normal valley level (Figure 2, Section B-B) and there is no suggestion of the hanging valleys to be expected at the junction of minor tributary glaciers with the trunk glacier.

Figure 3 is an echo-sounding run up Port Davey. This has a gross exaggeration of the vertical scale with respect to the horizontal, and in addition the line of steaming does not follow faithfully the sinuous course of the deepest part of the channel, so care is necessary in interpreting the echogram. Nevertheless, it does show that the lateral spurs continue down normaliy (for river erosion) below the water and show no signs of truncation as would have occurred in a fjord.

Characteristic of fjords is the threshold, and " skerryguard " islands are common features (Charlesworth, 1957, p. 343). Breaksea Islands could fit the latter role admirably, and there are bar-like shoalings of each channel at the mouth which could be a low threshold. The water shoals to five fathoms in the north channel and to seven fathoms in the south channel (the maximum interior depth is 22 fathoms). But bars of these dimensions are equally characteristic of estaury mouths. There is a substantial catchment of high rainfall country draining through Bathurst Channel, and although the coarse sediments are largely dropped in Bathurst Harbour, suspended material tends to be flocculated at the estuary mouth. The mouth then is compatible with the fjord theory, but is equaliy compatible with drowning.

Finally, the fjord-making glacier, if it existed, can only have come from Bathurst Harbour. This is a broad flat-floored pan several miles across at sea level (see Figure 4). To feed the fjord glacier, this would have to have been filled by an ice-cap. Now, this ice-cap would have had equally easy outlet via Melaleuca Inlet to Cox's Bight. This, too, would have been occupied by a distributary glacier of at least comparable dimensions to that in Bathurst Channel. There is no evidence to suggest a glacial valley or fjord here, and much to the contrary.

Conclusions

Since Lewis did not, to our knowledge, publish any evidence to support his view, there is no existing case to be answered. As a result of the total absence of positive evidence of glaciation, and the strength of the evidence presented above inconsistent with glaciation, the authors do not agree with Lewis's view, now generally accepted, that Port Davey is a fjord. We conclude that Port Davey, Bathurst Channel and Bathurst Harbour are a drowned river estuary, the drowning having caused dismemberment of a fairly large river system.

Acknowledgements

The authors wish to thank Mr. J. G. Symons, Director of Mines for Tasmania, for making the Port Davey investigations possible. The help of Professor S. Warren Carey and Mr. M. R. Banks, of the University of Tasmania, is also gratefully acknowledged.

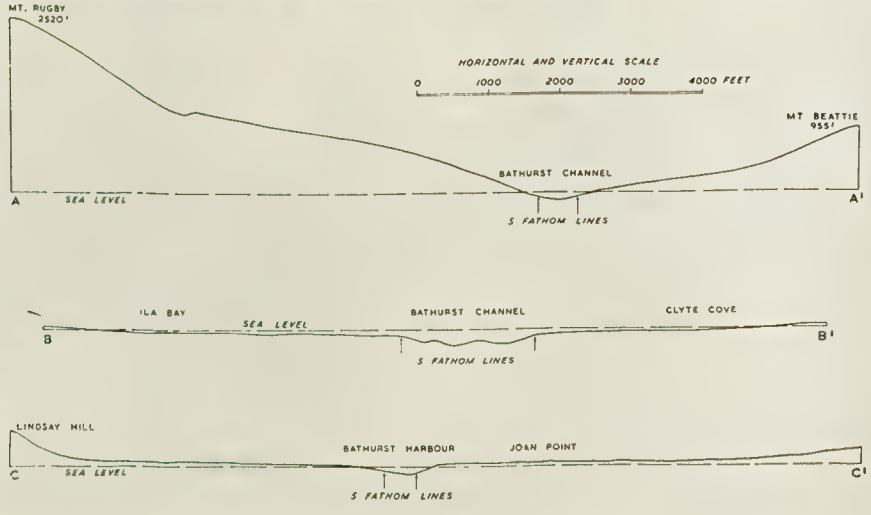

Figure 2

CROSS SECTIONS OF BATHURST CHANNEL AND ADJACENT TOPOGRAPHY

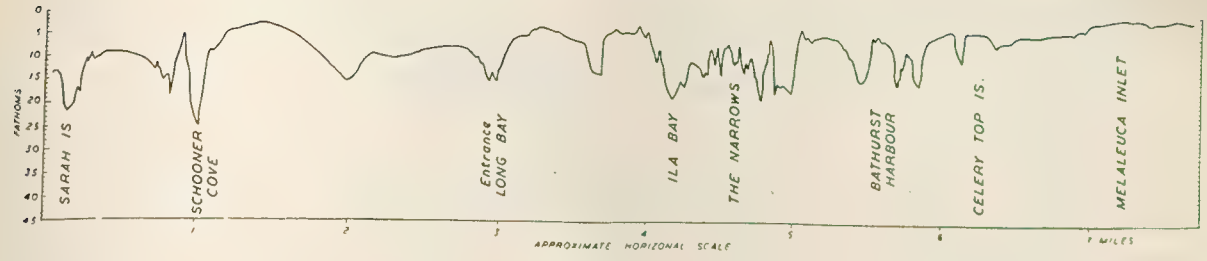

Figure 3

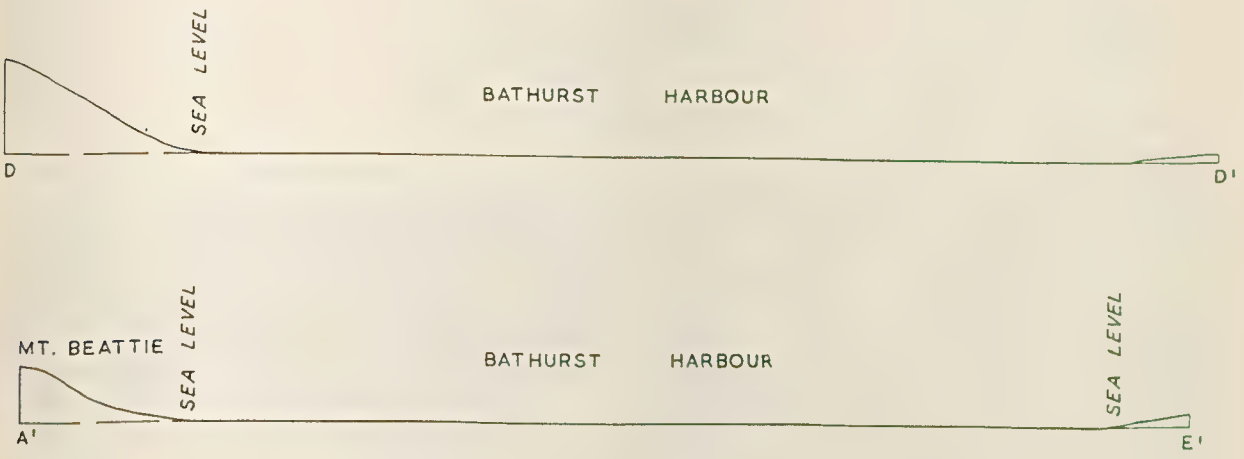

Figure 4

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NOTES ON THE CAINOZOIC HISTORY OF WESTERN TASMANIA— "MALANNA" GLACIATION

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(With 4 Text Figures)

ABSTRACT

The Cainozoic history of the Malanna area included faulting, deposition of sediments by streams or in lakes and swamps, two epochs of planation, and stream erosion. There is no physiographic, depositional or structural evidence for glaciation in this area, the type area of Lewis's Malanna Phase of the Pleistocene glaciation. This phase must be considered invalid on the evidence available in the type area and the term "Malanna Phase" should be abandoned.

INTRODUCTION

Gregory (1904, p. 51) first described the sediments near Malanna which were later considered to be morainal and adopted by Lewis as the type feature for his Malanna Glacial Phase of the Pleistocene glaciation. Gregory considered them to be glacial because of the presence of boulder clay containing boulders of very decomposed dolerite. Because of the depth of weathering of the boulders and "lack of indication of recent glaciation in this locality", he provisionally assigned a Carboniferous (Permian of present day nomenclature) age to the glaciation. Later Loftus Hills showed these deposits to David, who was impressed by the shattering of the Permian rocks at Malanna and influenced by the flat-floored, steep-walled valley of the Eden Rivulet (now Badger River) and perhaps also by the morainal form of some of the hills near Firewood Siding and Koyule (see Fig. 2). David (1926) also considered the deposits near Malanna to be glacial and, because of the impressions he had gained of the physiographic effects of glaciation, he considered them to be Pleistocene. On the grounds of depth of decomposition of the dolerite boulders and amount of river erosion since the supposed glaciation he considered that the "Malanna Moraine is at least as old as Mindel, and possibly even as old as Günz". The presence of dolerite boulders, the lack of known outcrops of dolerite in the neighbourhood and the supposed glaciation forced David to postulate transport of dolerite from Mount Sedgwick, twenty miles away, by an ice sheet, as Mount Sedgwick was, and still is, the nearest known dolerite-capped mountain showing glacial effects. In 1934 Lewis designated these deposits as the type evidence for his Malanna Phase.

Gill and Banks (1950) visited the area and made observations on the older rocks. In 1953 K. G. Brill, G. E. Hale and M. R. Banks visited the area and K. G. Brill made the important discovery that there was a large outcrop of dolerite less than one mile north of Firewood Siding, and less than half a mile from the nearest "morainal" deposit. Detailed sections were measured in some of the cuttings. In 1957 the present authors visited the area in an attempt to solve the outstanding problems connected with the glaciation but, after a few days further observation, concluded that there was no evidence at all for Pleistocene glaciation in this area and that all the features could be produced by Tertiary faulting and normal erosion.

Method of Measuring Heights

Heights quoted along the railway line and south of the Henty River are those for a series of survey pegs which were established by R. Braybrook, Hydro-Electric Commission surveyor, as part of an air-photo control survey. The heights of the survey pegs are related to mean sea level at Hobart. The four heights not on the railway line were measured in 1957 by an aircraft altimeter capable of reading to ten feet. The heights were found by reading on the survey pegs, then on the various physiographic features and then onto the same or another survey peg. Maximum time between successive readings on survey pegs was twenty minutes.

The authors wish to acknowledge helpful criticism of the manuscript by J. L. Davies, Geography Department, Professor S. W. Carey and Dr. E. Williams, Geology Department, University of Tasmania.

PHYSIOGRAPHY

The Malanna area is situated north of the mouth of the Henty River, a couple of miles inland from the western coast of Tasmania (see map, fig. 1).

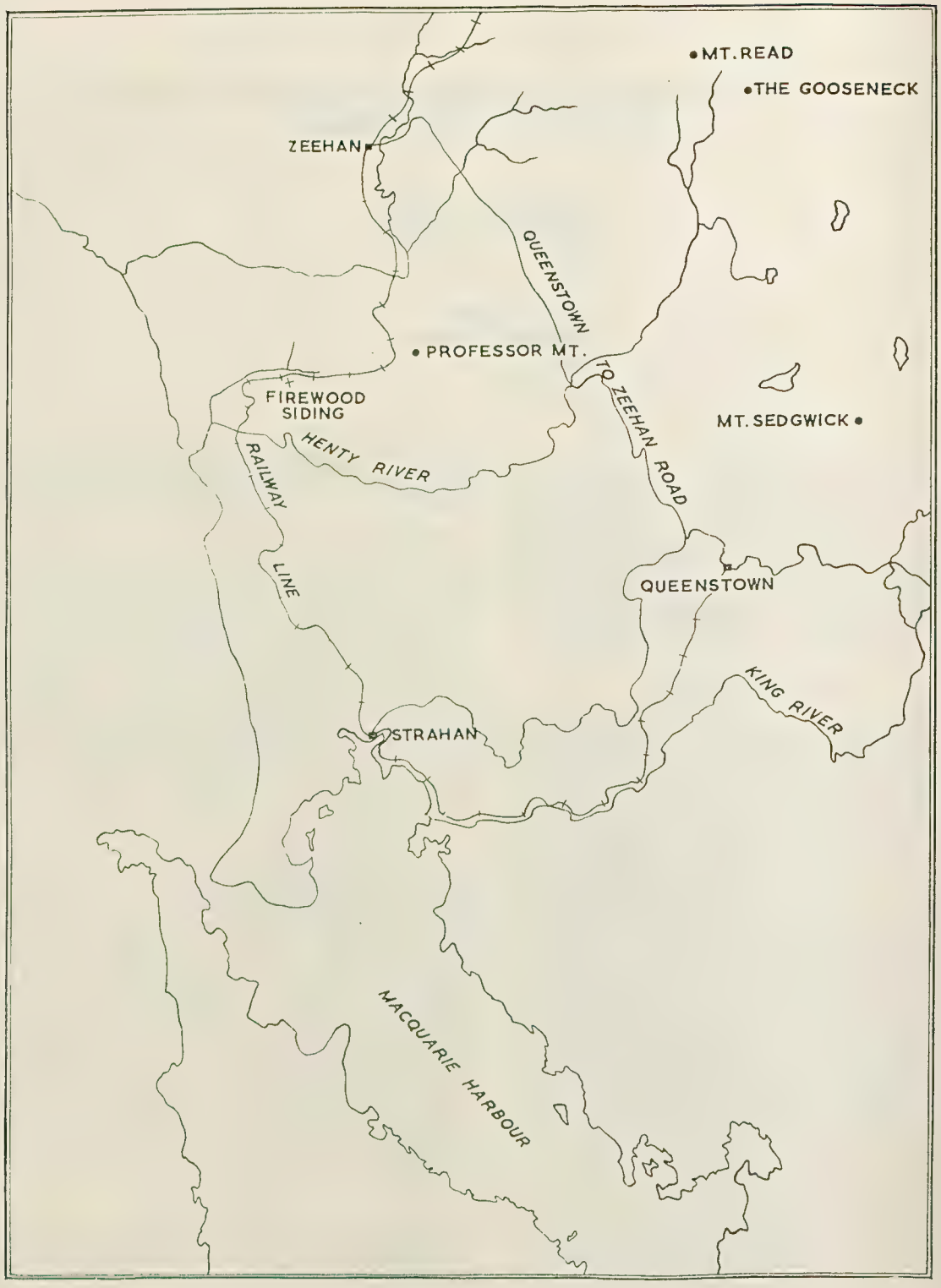

MT. READ
THE GOOSENECK
ZEEHAN
QUEENSTOWN
PROFESSOR MT.
TO ZEEHAN ROAD
FIREWOOD SIDING
MT. SEDGWICK
HENTY RIVER
RAILWAY LINE
QUEENSTOWN
KING RIVER
STRAHAN
MACQUARIE HARBOUR
N
SCALE
0
4
8
12 MILES

FIGURE 1

The main drainage of the area is by the Badger River to the north and the Henty River to the south. The Badger River rises about four miles to the east on the western slope of Mount Professor (see Gill and Banks, 1950, pl. III). From its source to about half a mile east of Firewood Siding the river flows in a swampy plain about half a mile wide which has a height of about 360 feet above sea level about a mile east of Firewood Siding. The plain lies between steep scarps on both sides and the river flows mainly near the western or northern boundary of the plain (see Gill and Banks, 1950, pls. I and III). There is one low, sharp ridge on the plain which parallels the western and northern wall and is about twelve chains from it. The main tributaries above Firewood Siding enter the Badger River from the east and south and are approximately at right angles to the scarp bounding the plain. In this part of its course the western and northern scarp is in Crotty Quartzite, the river plain in Gordon Limestone with a sandy band in it which is represented topographically by the small ridge on the plain, and the eastern and southern scarp a dip slope in Owen Conglomerate and Caroline Creek Sandstone. From its source to about half a mile east of Firewood Siding, the Badger River and its tributaries are strongly structurally controlled; the river follows the strike of the Gordon Limestone and the tributaries are perpendicular to the strike around the noses of a north-west-plunging anticline and syncline. Only minor streams join the Badger River from the scarp of Crotty Quartzite. The Badger River is separated at its source in the north by a low divide from a stream cutting down through the Crotty Quartzite and finally flowing into the Little Henty River. The divide is within the plain and is only a few feet high. After crossing the Eden Fault (see fig 2) half a mile east of Firewood Siding the Badger River enters a valley tract (of Hills, 1946) in which it is cutting into Permian rocks. The main tributaries now enter from the north and are more or less parallel to the strike of the Permian rocks. About thirty chains west of Firewood Siding the river enters a mountain tract (of Hills, 1946) in which it is entrenched in the sandstones of the Cygnet Coal Measures. Further downstream the relief is lower but the stream still in mountain tract until about one and three quarters of a mile west-south-west of Firewood Siding it opens out into a valley tract before turning south and flowing between vegetated dunes to the east and intermittently moving dunes to the west.

Loftus Hills is credited by Lewis (1926, p. 88) with the discovery of a small glacial valley superimposed on a broader glacial one in the Eden Valley. David (1926, p. 91) implies that the Eden Valley (now Badger Valley) had suffered "very ancient glaciation", but in neither case was any detailed physiographic evidence offered. At first sight, the Badger Valley might appear glacial because of the steep side slopes, the flat floor and the gentle curve of the valley in plan. These features of the valley are the result of normal atmospheric and stream erosion in a topography of rocks of varying competence, the incompetent Gordon Limestone lying between the resistant formations, Owen Conglomerate and Crotty Quartzite. A local base level developed in Permian rocks, just east of Firewood Siding, has caused the erosion to that level of the Gordon Limestone in the Badger Valley. The entrenchment of the Badger River west of Firewood Siding may be due to rejuvenation, possibly associated with faulting or fall in sea level, with headward movement of the knick point (see fig. 2). The Badger River valley shows no physiographic evidence of glaciation.

The main stream draining the area is the Henty River, which rises about sixteen miles to the north-east on the slopes of Mount Read and the Gooseneck and flows through the Henty Surface as an entrenched, youthful stream to within a mile or two of the Malanna area. It is still in mountain tract to within a mile of the railway bridge, but below this shows some depositional features near present river level. The Henty River north of the Queenstown-Zeehan Road is glaciated and the terminal moraines of the glacier which occupied the Henty Valley occur a few hundred yards below the road bridge over the Henty River (Bradley, 1954, p. 196, and Yolande River Sheet). The exact level of the foot of these moraines is not known but it is probably not more than forty feet below the bridge which has a height of 282 feet above sea level (H.E.C. Bench Mark). Below these moraines the Henty River is in a typical mountain tract and there are no further signs of glaciation.

The area between the railway line and the Henty River is drained by west-flowing streams and by Geologists Creek. In all cases the headwaters are in wide, low valleys and swampy conditions are common. Further down their courses the streams pass into steep, narrow, mountainous valleys before entering short valley and plains tracts prior to joining the Badger or Henty Rivers.

The surface topography of the area might, perhaps, be considered in terms of a number of erosional surfaces. The highest of these is the Henty Surface (of Gregory, 1903; not Bradley, 1954). This extends from the foot of the West Coast Range, where it has a height of from 1,100 to 1,200 feet above sea level, to the Malanna area. In the Malanna area a height was measured on a hill of Crotty Quartzite (Gill and Banks, 1950, pl. I, western photo, 1.5 cms. S.W. of centre point) which forms part of this Henty Surface. The height is 720 (±10) feet above sea level, giving an average slope to the sea of about 60 feet per mile. Immediately south of Firewood Siding the heights of two hills in Permian sandstone and conglomerate were measured and found to be 525 (±5) and 560 (±5) feet (averaged figures) above sea level. The higher, easternmost one, is about two miles from the hill of Crotty Quartzite measured and the seaward slope is of the same order as that for the main part of the Henty Surface. North of Firewood Siding a sharp ridge of Permian and a hill of dolerite appear to reach a similar height to the hills south of Firewood Siding and to be accordant with flat-topped hills to the north, forming part of the Henty Surface. Thus the hills immediately south of Firewood Siding are considered to form part of the Henty Surface.

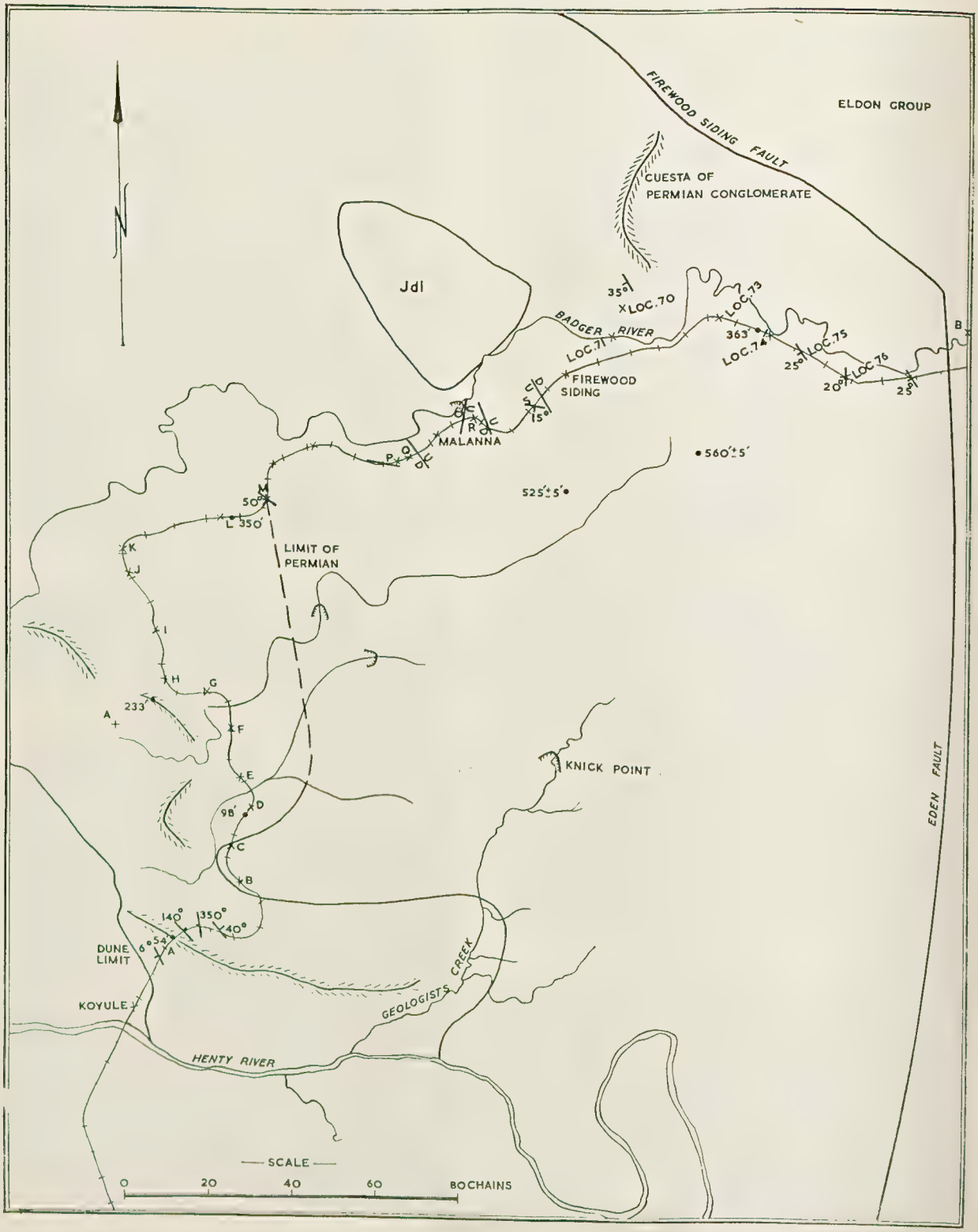

FIREWOOD SIDING FAULT
ELDON GROUP
CUESTA OF PERMIAN CONGLOMERATE
Jdl
35°
LOC.70
BADGER RIVER
LOC.71
LOC.73
363°
LOC.74
25°
LOC.75
20°
LOC.76
25°
B
FIREWOOD SIDING
MALANNA
15°
560'±5'
525'±5'
50°
M
L 350'
LIMIT OF PERMIAN
K
J
I
H
G
233°
A
F
E
98'
D
C
B
KNICK POINT
EDEN FAULT
140°
350°
40°
6°54'
A
DUNE LIMIT
KOYULE
GEOLOGISTS CREEK
HENTY RIVER
SCALE
0 20 40 60 80 CHAINS

FIGURE 2

Sections of Malanna Area Showing Physiography and Structure

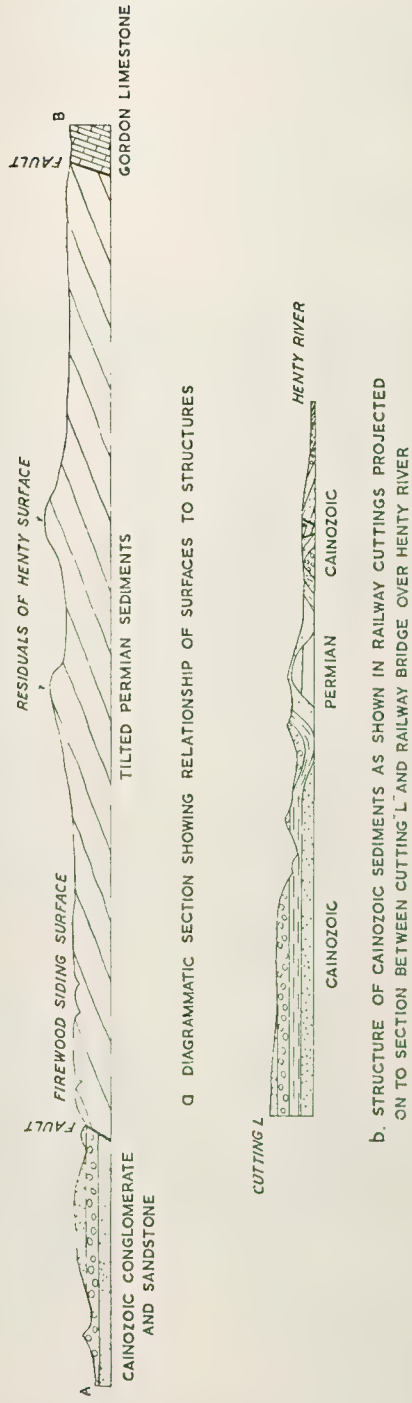


FIGURE 3

Between these hills and the Henty River is a flattish area cut in dipping Owen Conglomerate and tilted Permian sediments. This rises abruptly along steep scarps to the north and falls abruptly to west and south along steep scarps. To the east it continues across Permian rocks and the Junee Group until it reaches a more resistant bed in the Owen Conglomerate which forms a steep dip slope about one and three quarters of a mile south-east of Firewood Siding. This surface is drained by wide, flat valleys. It is an erosional surface truncating the tilted rocks (see figs. 2 and 3). No heights have been measured on this surface, but from ground observations it would appear at its north-western end to be a few feet lower than the top of the Tertiary sediments (350 feet above sea-level). It rises somewhat to the east where it is a little higher than the height of the Badger River plain about a mile east of Firewood Siding, i.e., about 360 feet above sea-level. This surface at from about 350 feet to about 400 feet might be called the Firewood Siding Surface. Separating this surface from the present plain of the Badger River is an east-facing obsequent fault-line scarp of the Eden Fault about 40-50 feet in height. The plain east of this scarp is in Gordon Limestone that to the west in more resistant Permian mudstone and sandstone. Another flattish area occurs on the northern side of the Badger River north-west of Malanna. This also is eroded in tilted Permian sediments and is at about the same level as the Firewood Siding Surface.

The sharp ridge north of Firewood Siding is a compound one as a fault appears to pass across it near its southern end. Near the southern end it is made up of two connected cuestas, but a structural control for its northern end is not clear. The hills south of Firewood Siding forming part of the Henty Surface have steep southerly-facing scarps and gentler, although still steep, northern slopes. The southern scarp is a cut-off scarp of the creek shown on the map (fig. 2) now dissecting the Firewood Siding Surface. The northern slope is not a dip slope as shown by numerous dip readings in the Permian rocks in the railway cuttings.

On the hills east of Henty Siding, a siding about a mile south of the railway bridge over the Henty River, there are exposures of gravels containing large blocks of Permian sandstone and dolerite. These form part of a surface at about 300 feet above sea level. The hill west of cutting H has a height of 235 (± 5) feet above sea-level, and is more or less accordant with the hills immediately to north and south. The maximum height reached by the Tertiary sediments (in Cutting L, fig. 2) is 350 (±5) feet above sea-level.

Further west is a low sand-covered area, now vegetated, and beyond this an area of active dunes.

The two surfaces in the area, the Henty Surface and the Firewood Siding Surface, show no signs of glaciation in this area. The Firewood Siding Surface is shown on Gregory's map (1903, pl. XX) as part of his Western Peneplain. On neither surface are there any erratics locally, no ice polished, nor ice-scoured surfaces, and no sign of ice plucking. Although David noted roches moutonnées in the Eden Valley, he gave no details and the present authors are unable to find any. There are no

signs of the passage of ice over any of the scarps and some of the ridges, e.g., that just south of Firewood Siding containing the measured hills, have steep irregular faces to the east (the alleged direction from which th ice sheet came) and a more gentle slope to the west. The sharp-crested ridge north of Firewood Siding is very steep sided and, in plan, convex to the west. It could, on superficial examination, be mistaken for a moraine, especially as it has blocks of rock scattered over its surface. However, detailed examination of this ridge shows it to be, at least partially, a cuesta in Upper Permian quartz sandstone and conglomerate and the scattered boulders to be entirely of these materials.

The Firewood Siding Surface is succeeded to the west and south by an area of lower hills (see fig. 3, *a*). Just south of the Badger River is a south-east-trending fairly-sharp-crested ridge cut by a south-westerly-flowing stream. In many places the crest of the ridge is demonstrably pebbly. Its height is 235 (± 5) feet above sea-level. South of the end of this ridge and separated from it by a deep valley is a sharp-peaked hill with a slight tendency to a south-south-westerly trend then a swing to the south-east. No outcrop occurs but boulders and pebbles are spread over the surface. This is separated by a creek valley and a swampy flat from a ridge which is cut by the railway line just north of Koyule and trends east-south-east. The surface of this ridge is gravel-covered, but the railway section reveals the presence of other types of sediments. It is clear that the ridge is not a depositional feature and, where cut by the railway line, it is anticlinal in structure. A superficial examination of these ridges may well suggest terminal moraines, more or less convex to the sea, later breached by streams. However, the section through the southern one clearly shows that it is not morainal and sections in railway cuttings just behind the others suggest the same. These considerations, together with a lack of glaciation in the hinterland, indicate that these ridges are not moraines. Thus, in the Malanna area, there is no physiographic evidence of glaciation.

CAINOZOIC DEPOSITS

The earliest record of Cainozoic deposits in this area is that of Montgomery (1890), who noted the presence of clays in the first creek valley west of the railway bridge and near the Henty Ferry and suggested their equivalence to the Macquarie Harbour Beds. In 1892 Johnston noted the presence of lignite in the same area and recorded a *Fagus* close to *F.* (now *Notofagus*) *cunninghami* and an *Acacia* close to *A. melanoxylon*. To him the close resemblance of these two forms suggested that the lignites were "of a more recent date than any other lignite formation hitherto described". Gregory (1904, p. 51) described some of the rocks in the railway cuttings. Boulder clays with boulders of Owen Conglomerate and decomposed dolerite up to two feet across were mentioned. Gregory described the boulders as lying at all angles and having a shape characteristic of ice-action, most of them having one or more flattened surfaces. David (1926, pp. 94-95) described the blocks in the northernmost railway cutting as up five feet in diameter and all rounded, although elsewhere on p. 95 he states that the shape of many is obviously glacial. In a footnote on page 102, David notes that the sequence is more complex than he had depicted. He states that the redistributed glacial beds at Henty Siding pass below sea level, are capped by lignitic shale and sandstone, and faulted.

It will be convenient to describe the deposits exposed in the railway cuttings between the railway bridge over the Henty River and Malanna in order from south to north.

Cutting A (see map)

At the southern end of the cutting a succession dipping 240° at 6° is exposed. At the base is a bed of gravel at least twelve feet thick and consisting mainly of rounded boulders of dolerite up to 30 inches long with some boulders of Permian sandstone, siltstone and conglomerate. Some of the boulders are sub-angular to angular. There is a suggestion of an upward decrease in grain size, although this is not marked. This is overlain by two feet of clayey sand and then one foot 10 inches of clayey pebbly sand with lignitic fragments used in radiocarbon dating. This latter bed of sand is cross-bedded, and contains some conglomerate bands in which there are pebbles of siltstone. In both of these sandy beds there are branching, cylindrical ferruginous concretions which are in some cases around lignitic fragments. The next bed is a conglomerate composed mainly of fragments of Permian siltstone with some lignite fragments. This is 1′ 8″ thick at its northern end but thickens to the south-west and becomes more conglomeratic in that direction. Some cross-bedding is present in the sandy matrix and the currents came from the north-east or north. This conglomeratic bed has an irregular lower surface and this forms a prominent overhang in the face of the cutting. The final bed in this succession is at least 15 feet thick and consists of gravels with sandy lenses showing cross-bedding indicating currents from north-east or north. Some clay lenses are also present. The main boulders are composed of Permian rocks and dolerite.

This succession is affected by two normal faults forming a small graben with a throw of a few feet. Further north in the cutting the succession is hidden for an interval by sand and vegetation. Beyond this gravels again occur. They are sandier than those in the southern end of the cut and contain rounded boulders of dolerite near the base, with boulders of Permian rocks and Owen Conglomerate becoming more common near the top. At the extreme northern end of the cutting these are overlain by a lignitic bed, then more gravels, sand, and finally a lignitic bed. The lower of these lignitic beds dips 50° at 40°. About half-way along the western wall of the cut sands and interbedded carbonaceous sand or peat abut disconformably against the gravels.

Cutting B

This cutting is mainly in Permian rocks which are described elsewhere (Banks and Ahmad ms). The Permian rocks are overlain by a bed of gravel

two feet thick which, in one place near the southern end of the eastern bank of the cutting, occupies an old gully a few feet deep. The gravel is sandy and contains rounded to sub-rounded angular boulders of Owen Conglomerate, quartz, quartzite and Permian sandstone. This is overlain by about three feet of soil.

Cutting C

In this cutting Permian rocks are overlain by a couple of feet of gravel and then about three feet of soil.

Cutting D

The beds in this cutting dip 85° at 28°. At the base is a cross-bedded sandstone with some gravelly layers, which becomes lignitic and clayey towards the top. This is followed by sand and then, after a slight gap, sand with layers of peaty sand and boulders. Another cross-bedded sandstone follows. It is pale yellow-brown in colour and has rare boulders. The cross-bedding is due mainly to currents coming from the north-east. This sandstone passes up into the sandy clay, clay and then lignite. The top beds in the cutting are pebbly sands with three thin beds of boulders near the base and a bed of pebbles higher up. Cross-bedding dipping south-west is present. Boulders in these cuttings include those of Owen Conglomerate, Permian sandstone and weathered dolerite. These beds are overlain by a gravel is in Cuttings B and C.

Cutting E

At the southern end of this cutting there is a gravel with boulders up to four feet long which is rudely bedded and contains pockets of pebbles. There is a high proportion of boulders in the gravels, which range in size from a quarter of an inch up. The boulders are well rounded but the sphericity is frequently low. The boulders include those of dolerite, weather and fresh Permian rocks, including conglomerates and sandstone, quartzite, clay and Tertiary sandstone. The small dolerite boulders are completely weathered, the larger ones to a lesser extent. This part of the cutting is overlain by about three feet of soil.

To the north the gravels are overlapped by white cross-bedded, sandstones with interbedded clays and lignified wood, seeds and leaves with some pyrite nodules. Some of the larger fragments of lignified wood are still standing upright (i.e., are in growth position). The cross-bedding appears to be due to currents coming from the north-east. The succession in this part of the cutting dips 230° at 26° and is overlain unconformably by a surface gravel with boulders of Owen Conglomerate.

The succession was measured in some detail and is shown below:—

Top:
Gravel with boulders of Owen Conglomerate.
Unconformity.
18 feet: White, fine to medium grained sandstone with thin bedding.
1 foot: Coarse siliceous conglomerate with boulders of Permian sandstone.
4. feet: White, medium-grained, unbedded quartz sand.
1 foot: Coarse, siliceous conglomerate with boulders of Permian sandstone.
4 feet 6 inches: Grey clay with lignified plant remains near top and about one foot from top; top foot is fissile; some pyrite.
3 feet 6 inches: White, grey or white with red streaks, clay with cylindrical, spherical, branching and irregular limonitic nodules.
7 feet: Yellow to white, fine to medium grained sandstone, consisting of quartz with clay cement; friable; grains sub-angular to sub-rounded with a few pebbles.
5 feet: White, medium-grained sandstone with occasional bands of pebbles of Permian sandstone.
1 foot 6 inches: Conglomerate with rounded, elliptical pebbles and cobbles up to eight inches long, mainly of Permian sandstone.
1 foot: Medium-grained sandstone without pebbles.
9 feet: Sandstone with coarse bands of angular grains, with 9-inch pebble band with angular to rounded pebbles of several sizes of quartz, quartzite, Owen Conglomerate and Permian sandstone.
13 feet: Very pale, sticky clay.
4 feet: Gap in section.
6 feet 6 inches: Pale-brown, cross-bedded sandstone.
2 feet 6 inches: Clay, grey, with plant stems and some carbonaceous bands.
6 feet 6 inches: Pale-brown, cross-bedded, finely-bedded sandstone; quartzose, mostly fine-grained bed, some beds of medium to coarse grained sand; in the latter of which the grains are distinctly angular.
16 feet. Grey clay with plant stems and some carbonaceous bands.
26 feet. Sandstone, white to yellow, medium-grained, quartzite, thinly bedded.
5 inches: Conglomeratic, yellowish sandstone.
13 feet: White to pale-yellow sandstone with a few conglomeratic bands.
9 feet: Conglomerate sandstone with cross-bedding on small scale, dipping south-west; sub-rounded, sub-angular and some rounded pebbles and cobbles up to six inches long of Owen Conglomerate and Permian sandstone.

153 feet (approx.).

At the northern end of the cutting the south-westerly-dipping basal beds in the above succession are overlain unconformably by gravels with boulders of Owen Conglomerate.

Cutting F

At the southern end of this cut a fault throws cross-bedded sandstone to the south against beds of gravel and cross-bedded sand to the north. The cross-bedding dips north. The beds are almost horizontal and are from one foot to two feet thick. The boulders, which are up to three feet long are sub-angular to sub-rounded and rounded. They consist of Permian sandstone and siltstone, quartzite, quartz and dolerite. Many of the boulders are deeply weathered. The total thickness is about 30 feet. Further north again are sands containing a few large pebbles.

Cutting G

The main rock-type is a conglomerate lacking bedding and containing sub-angular to sub-rounded boulders up to several feet in diameter, with a few rounded ones. They consist mainly of Permian sandstone which is deeply leached and exfoliated. The matrix is sandy and there are some sandy bands, one of which is at least is in a washout.

Cutting H

Gravels are overlain by sands. The boulders are up to four feet long and are mainly Permian sandstone near the base but a few dolerite boulders occur near the top. The sands are cross-bedded with the dip of the cross-bedding to the south.

Cutting I

Sands at the base are overlain by lenses of gravel, followed by more sands and then gravel. The dip is at a low angle to the south. The top sands are cross-bedded with some of the cross-bedding traces in the cut dipping south-east, while most of them dip north-west.

Cutting J

Gravels with boulders more than three feet long are present.

Cutting K

The gravels in this cutting contain boulders up to five feet long. The boulders include those of Permian sandstone, and leached siltstone, with some quartz and quartzite. The gravels are interbedded with a fine-grained sand showing cross-bedding dipping north. A washout in the sands is filled with the conglomerate.

Cutting L

This is the last cutting in which Cainozoic deposits occur. They are gravels with many boulders up to a few feet long of Permian sandstone with a few boulders of dolerite.

The Cainozoic deposits exposed in the railway cuttings consist, then, of more or less unconsolidated rocks, with gravels, cross-bedded sands, clays and lignites being represented. The gravels are commonly bedded and the boulders in them are mainly sub-rounded. No striated pebbles were found, although they were looked for. The rock fragments consist mainly of Permian sandstone, siltstone or granule conglomerate, dolerite, Owen Conglomerate, quartz and quartzite and, more rarely, fragments of clay or clayey sand or lignite. Some of these boulders are now deeply weathered. It is notable that there is a general increase in grain size in the boulders from south to north, boulders up to five feet long occurring in Cuttings K and L, but all the gravels are not necessarily contemporaneous. It is also significant that the rock types present are all potentially of local derivation and could all come from within three miles to the east. The matrix of the gravels is predominantly sandy and they contain little clay.

Cross-bedding in the sands south of Cutting F dips mainly to the south-west, but north of this cutting the dip of the cross-bedding varies and tends to be northerly in several places. The presence of lignite indicates that some of the beds, at least, are paludal and no marine macrofossils were seen. There are numerous disconformities and some unconformities, suggesting folding or at least tilting before deposition of the later beds.

The radiocarbon dating indicates an age greater than 32,000 years for some of the lignites in Cutting A (Rubin, M, and Alexander, C, 1958, W444, p. 1483). This specimen was submitted on the mistaken idea that the conglomerates in this cutting were morainal and associated with the Malanna glaciation. A considerable age for most of the gravels is indicated also by the extent of weathering of the dolerite boulders. The deposits are clearly post-dolerite, the dolerite probably being Lower Jurassic. Some of the material from the lignitic beds in Cutting E was submitted to Dr. I. Cookson for palynological analysis. Seeds and seed cases on cones of *Banksia* cf. *marginata* were reported from the sample, so that a Cainozoic age seems likely and possibly an Upper Cainozoic age in view of the close resemblance of the seed cases to forms still living in the area. Final dating must await detailed palynological work but the beds might best be considered Upper Cainozoic and this would be in accord with Johnston's record (1892, pp. 12-13) of *Acacia* from this area.

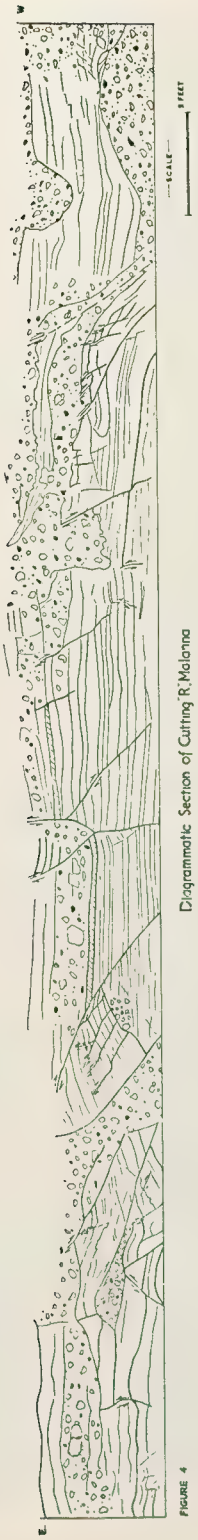
The rocks in the cuttings thus provide no evidence of a glacial origin and there is no physiographic evidence for glaciation in the area. On these grounds alone the hypothesis of the existence of a Malanna Phase of the Pleistocene Glaciation in the Malanna area, must be considered invalid. Before providing an alternative explanation for the observed facts, a final point in David's argument must be dealt with, that of the "brecciated pavements". To put the features so interpreted by David in their correct perspective the structure of the area must be considered.

STRUCTURAL GEOLOGY

The structure of the Lower and Middle Palaeozoic rocks to the east has been figured and briefly described by Gill and Banks (1950), is not relevant to the advancement of the argument, and will not be considered further. The Permian rocks near Firewood Siding are faulted against the older rocks. North of Firewood Siding is a fault, here called the Firewood Siding Fault, trending west-north-west and downthrowing to the south-south-west. This continues to about a mile east of Firewood Siding where a fault, the Eden Fault, trending north-north-east and downthrowing west, becomes the main structure. In general, the Permian rocks in the downthrown block dip to the south-west at angles varying from a couple of degrees to 50°, the latter occurring in Cutting M, that nearest the Tertiary beds, and suggesting a fault downthrowing to the south-west. The dips are all shown on the map (fig. 2).

In Cutting S there is a normal fault trending 330° (all bearings related to true north) and causing a distinct drag dip showing west side up. Joints trending 10° and 325° are common in this cutting. On some of the 325° joints are slickensides dipping west at a low angle and indicating west block north movement. Slickensides also occur on some of the bedding planes and show that the top moved west or north-west over the bottom.

Cutting R is that containing the rocks figured by David (1926, p. 102). At the eastern end of the cut the beds dip 115° at 30° and show joints trending 350° and dipping steeply west. Near the western end is a fault striking 340° and dipping west at about 45° and this is associated with much brecciation. In addition to these main faults, there are many minor normal faults dipping steeply west with a few normal faults dipping east and several minor thrusts dipping west. The beds affected are a formation of quartz sandstones and thinly-interbedded fine quartz sandstone and carbonaceous siltstones. The section figured by David is in the fine sandstone-siltstone alternation and



Diagrammatic Section of Cutting R, Malanna

FIGURE 4

these beds are consistently the ones showing the most brecciation and minor faulting. It is notable that in the main body of the cutting a bed of thickly-bedded quartz sandstone at the top of the cut is not affected by brecciation nearly as much as the underlying alternation of fine sandstone and siltstone. The structure along this section is shown as Figure 4.

Near the eastern end of Cutting Q is a normal, westerly-dipping fault striking 325°. In the body of the cutting the beds are horizontal. They are strongly jointed in places, the main joints trending north and showing horizontal slickensides indicating west side north movement. At the western end is a normal fault downthrowing to the east.

In Cutting P is a normal fault near the western end dipping 190° at 74°. In Cutting O the beds are almost horizontal, although in places they dip west and form a small monocline. They are disturbed by a small thrust dipping west and by joints mainly trending 340° but with some at 10°. The dip is west in Cutting N and there are minor faults. Joints are common, striking 120° and there are some parallel to the cutting which show horizontal slickensides. The Permian sandstone near the end of Cutting M dip 230° at 50° and this steep dip probably indicates a fault downthrowing south-west in the vicinity. Tertiary conglomerates in the next cutting west (L) appear to be horizontal. This may show that the fault is pre-conglomerate, but the cuttings are quite a few yards apart, so that the drag dip might lie due east of Cutting L.

The Permian rocks then show numerous normal faults, mainly trending north-westerly and forming small horsts and graben. With these are associated minor west-dipping thrust faults. The normal faults trend 330°, 340°, 325°, 10° and 280°. Joints trending 300°, 325°, 340°, 0° 10° and north-easterly occur. On the 325° set and the 0° set there is evidence of dextral movement and there is horizontal movement also on the north-easterly set. The faults are consistent with tension from S.W.-N.E. and some of the joints fit this pattern also. However, some joints do not seem to be related to this tension and a more detailed analysis is required. One case of bedding plane slip with movement down to the west or north-west was noted.

The major structures are quite inconsistent with faulting produced by an ice sheet moving from east to west. What thrusts are present dip west. The only evidence for ice thrust is the bedding plane slip but this could also occur with normal faulting of dipping beds.. Thus structures in the Permian rocks at Malanna used by David to support his hypothesis of glaciation in the area are inconsistent with this but consistent with normal faulting.

The Tertiary beds also show variations in the dip and some faulting (see fig. 3*b*). In the northern cuttings they are horizontal or nearly so. In Cutting E they dip 230° at 26° and in Cutting D they dip 85° at 28°, so that a syncline may be inferred, the axis trending roughly 340°, between these cuttings. In Cutting A the beds at the north end dip 50° at 40° and those in the south end dip 240° at 6°. An anticline, trending about 325°, would appear to be present. In Cutting F there is a fault with small displacement and in Cutting A two normal faults forming a graben. The northern one dips 260° at 45° and the southern one 50° at

50°. This graben would have a trend of about 335° and this is close to the main fault direction in the Permian rocks. Approximate coincidence of the fold axes with the fault directions suggests a genetic connection.

SOME ASPECTS OF THE GEOLOGICAL HISTORY

The Palaeozoic history of the Malanna area has been dealt with elsewhere (Gill and Banks, 1950, and Banks and Ahmad, ms). It is relevant to the present discussion only that the Lower and Middle Palaeozoic sediments were folded into plunging folds and then overlain unconformably by more or less flat-lying Permian sediments. Dolerite intrusions occurred in the Jurassic. At some later time the Firewood Siding and Eden Faults developed. The Henty Surface cuts across these faults and thus is later. This surface cuts across the Lower and Middle Palaeozoic rocks despite their differential resistance to erosion. It is, therefore, an erosional surface. Thin layers of gravel occur on it in places but there is no evidence that it is a stripped surface. It is certainly not a stripped pre-Permian surface as the Henty Surface extends inland to the foot of the West Coast Range where it has a height of 1,100 feet approximately. This range is probably a monadnock range as postulated by Bradley (1954, p. 195). The top of this range is probably part of the stripped pre-Permian surface (Bradley, 1954, p. 195), as shown by the Permian at Mount Sedgwick (Edwards, 1941), Mount Read and Mount Dundas, where the base of the Permian is at over 3,000 feet. The Henty Surface is now dissected by stream valleys up to 700 feet deep but some of the original surface remains, so that it is not likely to be as old as Early Tertiary. The surface was deeply dissected by rivers prior to the formation downstream from the Henty River road bridge of the terminal moraines. These moraines are dissected little except for the gorge cut through them by the Henty River and are thus probably not very old. Both the glacier responsible for these moraines and the glacier which occupied the Linda Valley are distributaries of the minor ice cap which occupied the West Coast Range between Mount Sedgwick and Mount Tyndall. The advance of the glacier occupying the Linda Valley has been dated as about 26,000 years, i.e., about equivalent to the beginning of the Wisconsin Glaciation, and the moraines below the Henty River road bridge might well be almost contemporaneous. They could probably safely be considered as Upper Pleistocene. Thus, the Henty Surface was formed well before the Upper Pleistocene.

The relationship of the sediments in the railway cuttings to the development of the Henty Surface cannot be established on evidence so far available in this area. They may have been deposited in lowlands in a pre-Henty surface of considerable relief. They may have been formed in a graben in this landscape delineated by the Firewood Siding and Eden Faults. The fault postulated between Cuttings L and M probably preceded the deposition of the gravels in Cutting L because of their horizontal disposition. At a later stage the Henty Surface would have been eroded in the Lower and Middle Palaeozoic, Permian and Cainozoic sediments. On the other hand the Cainozoic sediments may have been deposited as the Henty Surface was developing, streams stripping material off the higher country and depositing in the valleys until a surface, partly erosional and partly depositional, was formed. Yet again, the sediments may have resulted from uplift of the Henty Surface along a fault line between Cuttings L and M with formation of alluvial fans and fluviatile plains against the steep fault scarp. The sediments may have gradually filled up the fault lowland until they reached a profile of equilibrium related to the Firewood Siding Surface. No evidence is yet available to allow a choice between these alternatives.

The surface from which the Cainozoic sediments were derived must have had a considerable slope, at least in places, to account for the large particle size in the gravels. Boulders up to five feet in diameter in bedded deposits with a sandy matrix imply a considerable velocity and volume of water and thus a steep gradient. Variations in the competence of the depositional currents are shown by the occurrence of interbedded gravels, sands and clays. There is evidence of a systematic variation in current competence in the succession—gravel, sand, clay (with or without lignite)—which is developed completely or incompletely eight times in the sediments of Cutting E and three times each in Cutting D and Cutting A. The recurrent increase in competence represented by gravels, in many places associated with local disconformities, may be due to recurrent increases in rainfall following periods of lower rainfall, or to recurrent uplift due to faulting or lowering of base level. On several occasion peaty swamps were present. The cross-bedding in the sands suggests two sources, one to the north or north-east of Cutting L and the other somewhere between Cuttings E and F. Thus cross-bedding, dipping in a generally southerly or south-westerly direction occurs in most cuttings but cross-bedding dipping north or north-west occurs in Cuttings F, I and K. The presence of dolerite boulders in all cuttings suggests a northerly derivation, the dolerite mass near Firewood Siding probably being the source. The Owen Conglomerate boulders in the older deposits and superficial gravels in and south of Cutting E suggest a partial derivation of sediments in these cuttings from the east, the nearest Owen Conglomerate being about a mile and three quarters south-east of Firewood Siding. Some of these sediments are older than 32,000 years and some of them are older than the Firewood Siding Surface. In all cases it is probable that they are older than the last phase of the Pleistocene glaciation. Subsequent to deposition of the sediments in Cuttings A to E folding and faulting occurred. The trends of the folds and faults are almost parallel and this suggests genetic connection. They may well be due to slumping on a clay bed down a slope trending about 340° and dipping south-west. This roughly parallels many of the faults in the Permian rocks, and the slope may have been a fault scarp.

At some time after the development of the Henty Surface it was uplifted. Partial erosion of this surface produced the Firewood Siding Surface, cut in Lower Palaeozoic, Permian and Cainozoic sedi-

ments (at least those in Cutting L). The Henty River appears to have been a meander in this surface and after uplift was entrenched in it. At the time of development of the surface the Henty River locally had a height of about 400 feet relative to present sea level and must have been higher further upstream. As the terminal moraines on the Henty River have a height of only about 250 feet above sea-level at their downstream termination and there is no evidence of displacement or tilting of the Henty Surface between Malanna and the Henty River road bridge, the moraines must be later than the development of the Firewood Siding Surface. Thus this surface is pre-Upper Pleistocene. The surface falls from about 400 feet at the Eden Fault to 350 feet at Cutting L, a distance of about two miles, so that there is a fall of about 25 feet per mile. The base level controlling this surface is not known. "Beach terraces" at a level of about 400 feet above present sea-level are recorded by Twidale (1957, p. 12) from just north of the Pieman River, about sixteen miles north of the Malanna area, where they are incised into a higher plateau. No evidence is quoted for a marine origin for these "beach terraces", nor near Malanna are any marine deposits known at this level. It is not, of course, clear that the "beach terraces" and the Firewood Siding Surface are in any way related but there is some parallel in the relationship of the two features to a higher surface and sea-level. The Firewood Siding Surface postdates both the sediments in the railway cuttings and the Henty Surface. Since development of the Firewood Siding Surface there has been rejuvenation and the knick-point on the Badger River has moved upstream about three quarters of a mile.

For fuller and more accurate reconstruction of the Cainozoic history and palaeogeographies, detailed sedimentation studies will have to be made and some method of correlation evolved which is applicable to the terrestrial sediments. This may well involve comparison of quantitative pollen analyses of the lignites. In addition, more information on rock distribution and detailed study of contour maps of this and neightbouring areas will be needed.

SUMMARY AND CONCLUSIONS

After development of the Firewood Siding and Eden Faults in a terrain of Palaeozoic sediments and dolerite, erosion produced the Henty Surface. Before, during, or after formation of this surface, a thickness of at least a few hundred feet of terrestrial gravels, sands, silts, and lignites was deposited. The grain size of some of the gravels indicates considerable gradient for the transporting streams. The succession, gravels, sand, silt or clay, is repeated completely or incompletely at least eight times.

Uplift of the Henty Surface was followed by erosion which finally produced the Firewood Siding Surface. This latter surface developed after deposition of some of the sediments. Further uplift resulted in erosion of the Firewood Siding Surface. After this uplift glaciation affected the West Coast Range and the Henty River valley as far downstream as the road bridge about eight miles east of the Malanna area at a height of about 250 feet above sea-level. This glaciation was probably equivalent to the Wisconsin in the Northern Hemisphere. The uplifted Henty and Firewood Siding Surfaces are locally being dissected by streams which, at least in the Lower and Middle Palaeozoic rocks, are strongly structurally controlled.

In the Malanna area there is no evidence of Pleistocene glaciation, whether by ice-sheet or otherwise, and the physiographic, sedimentational and structural evidence advanced by David (1926) in support of glaciation in this area was misinterpreted. More detailed studies indicate that all the facts known about the area suggest a Cainozoic history involving faulting, deposition of terrestrial sediments by streams, or in lakes and swamps and erosion by streams. It is concluded, therefore, that there is no longer any justification for retaining the term "Malanna Phase" for a Pleistocene glacial phase based on this area. Use of the term should be discontinued.

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LOCALITY INDEX

	Lat.	Long.
	41° 50′	145° 30′
Badger River	41° 59′	145° 14′
Firewood Siding	41° 59′	145° 16′
Geologists' Creek	42° 00′	145° 16′
The Gooseneck	41° 52′	145° 33′
Henty River	42° 02′	145° 18′
Henty Siding	42° 02′	145° 15′
Malanna	42° 01′	145° 13′
Mount Professor	41° 59′	145° 22′
Mount Read	41° 50′	145° 30′
Mount Sedgwick	42° 00′	145° 35′
Pieman River	41° 50′	144° 55′
West Coast Range	41° 44′	145° 33′
	42° 18′	145° 38′

FOREST SUCCESSION IN THE FLORENTINE VALLEY, TASMANIA

By

J. M. Gilbert

SUMMARY

The topography, geology, climate and soils of the middle Florentine (lat. 42° 30′ S., long. 146° 30′ E.) are described. The vegetation consists of temperate rainforest, mixed forest (eucalypts with an understorey of rainforest species), eucalypt forest and treeless areas.

Except perhaps on the poorest soils, the climax is temperate rainforest and should the site be undisturbed by man (fire or axe) the climax condition is reached with the death, from old age, of the current generation of eucalypts which germinated at the last disturbance of the site.

The large areas of mixed forest date from past widespread fires. The rainforest species regenerate immediately after fire, i.e., at the same time as the eucalypts, and do not have to invade from the edge of the burnt area. However, should fires occur several times per century, the rainforest species will be drastically reduced or even eliminated.

The mixed forest is a fire-climax occupying a broad zone between the eucalypt forests of areas of lower rainfall and the rainforest of areas of higher rainfall and lower fire frequency. In the absence of fire the areas now occupied by mixed forest would carry rainforest and the ecotone between rainforest and eucalypt forest would probably be very steep and along the boundaries of poor soil.

I. TOPOGRAPHY AND GEOLOGY

The Florentine Valley (latitude 42° 30′ S., longitude 146° 30′ E.) is approximately 48 miles N.N.W. from Hobart, the river flowing from the south to join the middle course of the Derwent. This paper deals particularly with 12 miles of the middle Florentine from Tim Shea to Dawson's Road (Figs. 1.1 and 1.2).

In this region the valley is broad and flat (Figs. 1.2 and 1.3), the river meandering along the western side of the valley floor which falls at a rate of about 1 in 250. By contrast, in the last six miles of its course to the Derwent River, the Florentine falls 525 feet (1 in 60).

Dominating the valley, is the group of mountains rising steeply on the eastern side. From north to south the main points on this range are: Misery (2,500-3,000 feet), Lord (3,900 feet), Field West (4,720 feet), Florentine (4,100 feet), and Wherretts (3,300 feet).

To the west are the moderately steep slopes of the Tiger Range (2.000-2,500 feet)—the watershed between the Florentine and Gordon. Northwards, this continues as the Gordon Range, which culminates in Wyld's Craig (4,388 feet).

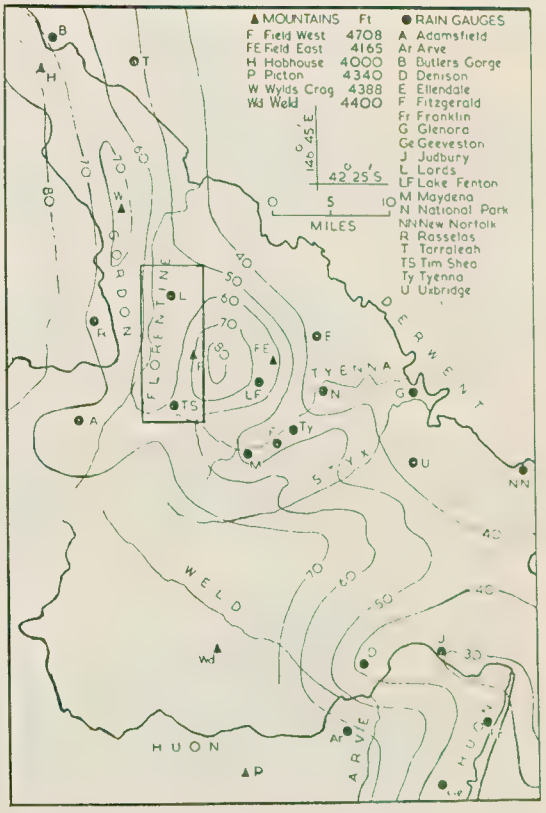

Fig. 1.1. Location of study area in Florentine Valley and annual rainfall (inches).

The Geology of the area has been described, as follows, by Banks (1957):—

> "The Florentine Valley is the eastern limb of the syncline of which the Tiger and Gordon Ranges form the axis. At its southern end, at Tim Shea, there is exposed the core of an anticline which plunges northwards into the syncline. The core of this anticline consists of Owen Conglomerate which is overlain by Caroline Creek Sandstone and Florentine Valley Mudstone.
>
> "The Florentine Valley Mudstone is overlain by Gordon Limestone, which forms the greater part of the floor of the valley. The limestone is cavernous. It is overlain in the Tiger and Gordon Ranges by quartizites and siltstones of the Eldon Group.

"Along the eastern face of the valley the Gordon Limestone is unconformably overlain by almost horizontal beds of Permian sandstones and mudstones. These beds are intruded by sheets of dolerite which now cap the ridges such as the Misery Range, Lords, Field West, Wherrett's Look-out (Wyld's Craig is also capped with dolerite). A series of faults along the western edge of the dolerite are down-thrown to the north-east.

"In the valley itself the Gordon Limestone generally dips steeply westward and in many places is overlain unconformably by unconsolidated, sub-horizontal beds of sand, gravel and cobbles. Near Lawrences Creek, these consist of fluvial gravels made up of rounded dolerite boulders. These may in part be fluvio-glacial as a small valley glacier occupied the head of the valley of the creek during part of the Pleistocene.

"Some beds of the Gordon Limestone have in places undergone selective silification and these beds are now represented by ridges covered with white angular fragments of cherty material containing silicified corals".

Throughout the floor of the valley and the lower slopes the surface drainage pattern is largely undifferentiated (subterranean drainage in limestone) and the surface is broken by local subsidences.

II. CLIMATE

1. General Pattern

Tasmania has a marine type of humid mesothermal climate (Cb of Trewartha—1954). The general weather pattern is imposed by Southern Ocean depressions. During the winter Tasmania is characteristically within the westerly air-stream with high pressure cells passing to the north of Bass Strait. Heavy rain may fall ahead of or along the cold fronts associated with the depressions, and showery weather continues often for several days with the strong westerly to south-westerly air-stream behind the front. If a depression causes an outburst of Antarctic air, snow falls.

In summer little rain falls ahead of the cold front. Should the depression be intense enough and have a trough extending into the Australian continent, hot, dry air of the Continental air-mass is brought in over the State. If forest fuels are already dry and these winds strong, any fires that occur will be severe (Gilbert, 1949). Such winds do not often blow for more than 24 hours.

Only scanty climatic information is available from the Florentine Valley itself and most of the records for nearby stations are for short terms.

2. Precipitation

The data in Table 1.1 indicate the monthly distribution of rainfall (for location of stations see Fig. 1.1.

TABLE 1.1.—MEAN MONTHLY RAINFALL IN POINTS.

Station: / No. of Years:	Maydena. 5	Lake Fenton. 15	Tarraleah. 21
January	350	386	369
February	341	448	361
March	299	425	283
April	387	506	362
May	334	532	413
June	383	573	360
July	464	555	500
August	477	600	629
September	582	651	691
October	485	596	442
November	381	596	331
December	403	472	549
Year	4,886	6,340	5,290

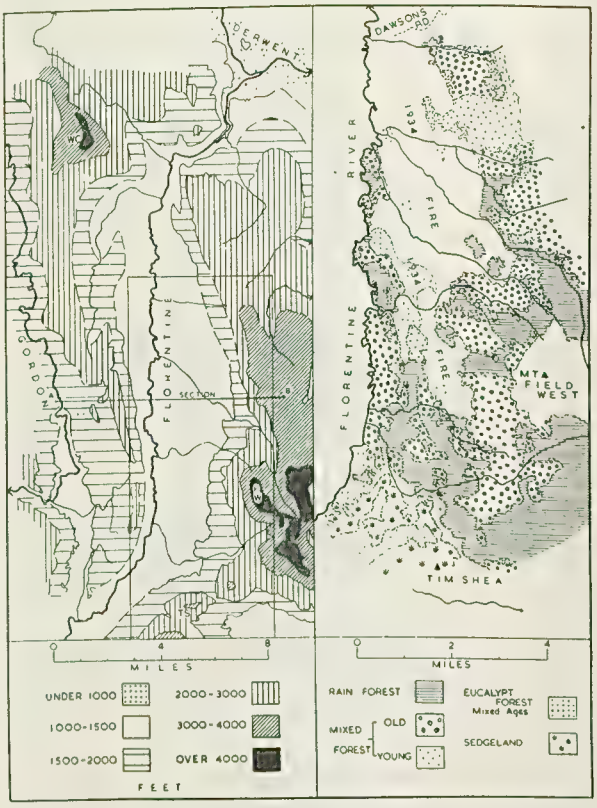

FIG. 1.2.—(*a*) Topography of Florentine Valley and surrounding districts. F.W.—Mt. Field West; T.S.—(Mt.) Tim Shea; W.C.—Wylds Craig.
(*b*) Distribution of forest types in middle of Florentine Valley. Complied from forest type map prepared by Tasmanian Forestry Commission.

Over three years (1955-57) the rainfall at Tim Shea averaged 59.97 inches and at Lords 47.27 inches for two years (1956-57). After considering data for long-term stations outside the Florentine (ratio of actual to mean catches for the years 1955, '56 and '57), the scanty information from the Florentine suggests that the mean annual rainfall at the southern end of the study area is 60-65 inches, and towards the northern end 50-55 inches.

In drawing the rainfall map (Fig. 1.1), some allowance has been made for the effect of topography and to some extent vegetation has been used as a guide. The 80" isohyet on the Field Range is justified by topography and by a comparison of the vegetation of the range with that near places such as the Cradle Valley, the Hartz-Adamson-La Perouse Range and the mountains near Lake St. Clair. Martin (1939) compared the development of the Austral-Montane shrubberies on several Tasmanian mountains and in particular referred to the relation between annual rainfall and the development of the dwarf endemic conifers. There are communities of *Diselma archeri, Pherosphaera hookeriana, Athrotaxis cupressoides* and *Microcachrys tetragona* on the Field West Range, which, following Martin, suggests that the annual rainfall is at least 80".

The seasonal distribution of rainfall for nearby stations is shown in Table 1.2.

TABLE 1.2.—SEASONAL DISTRIBUTION OF RAINFALL.

Station.	Elevation (feet).	Annual Rainfall (points).	% of Annual Rainfall.			
			Jan.-Mar.	Apr.-Jun.	Jul.-Sep.	Oct.-Dec.
Maydena	870	4,886	21	22	31	26
L. Fenton	3,450	6,340	20	25	29	26
Tarraleah	2,050	5,290	19	22	34	25

The winter bias is not extreme and 20% of the annual rainfall occurs in the three months, January-March.

Snow is to be expected in all parts of the area each winter. On the floor of the valley snow rarely remains for more than 1-2 days . On the lee slopes (E.-N.E.) of the Field West Range snow drifts may persist into January. It would be unusual for snow to lie for more than a few weeks in the *Eucalyptus gigantea* forest below 3,000'.

Fogs.—Low-level fogs are very common during the winter months and often do not disperse from the flats until mid-day.

3. Temperature

Short-term records are available from Maydena and Tarraleah (Tables 1.3 and 1.4). Maydena is within the *Eucalyptus regnans* forest belt, but Tarraleah is at a higher elevation and in *Eucalyptus gigantea* forest. The figures for Tarraleah are indicative of temperatures just belond the range of *regnans*.

From the data of Table 1.4 it is clear that frosts may occur at Maydena in any month. In the Florentine frosts are usually widespread but only one uncertain case has been observed of frost-heave of young seedlings. Rime may form on the crowns of eucalypts, even when more than 200 feet high.

4. Wind

The general pattern of the westerlies of the southern hemisphere have been described by Trewartha (1954). One of their distinguishing characterestics is "spells" of weather, i.e., at times, and especially during the winter, the wind blows with gale force, while upon other occasions mild breezes prevail. Moderate to strong winds (Beaufort scale 3-7; 8-38 m.p.h.) are most numerous, with strong winds (B. scale 8-12; 39-71 plus m.p.h.) more prevalent than weak winds (B. scale 1-2; 1-7 h.p.h.). Calms are infrequent. The westerlies are more boisterous on the average than the Trades.

In the Florentine Valley, winds are generally light from all quarters except N.W.-S.W. Precise information is not available from nearby weather stations, but some data for Hobart is representative except that the position of Mt. Wellington and the Derwent Estuary turn the W.-S.W. stream winds to N.W.

TABLE 1.3.—MONTHLY MEAN MAXIMUM AND MEAN MINIMUM SCREEN TEMPERATURES.

Station	No. of Years.		°F. J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Yr.
Maydena	4	Mean:													
		Max.	72	71	67	59	54	49	49	51	56	58	61	67	60
		Min.	46	47	43	42	38	35	33	35	36	38	41	44	40
Tarraleah	*	Mean:													
		Max.	65	68	64	58	52	46	46	49	53	57	61	75	57
		Min.	44	44	42	41	34	31	31	33	34	36	40	42	38

* Unofficial station: basisfor means uncertain.

TABLE 1.4.—ABSOLUTE MAXIMUM AND MINIMUM SCREEN TEMPERATURES AT MAYDENA, 1952-57.

Month:	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Yr.
Maximum	91	90	87	76	68	66	58	64	72	71	86	92	92
Minimum	34	31	30	30	28	22	20	22	23	26	32	38	20

For the period 1930-1947 the annual wind-gust maxima were distributed as follows:—

Wind Speed, m.p.h.

51-55	56-60	61-65	66-70	71-75	86-90
4	1	4	5	3	1

The lowest maximum was 54 m.p.h. in 1931, the highest 87 in 1946.

For the 34-year period (1922-56) the frequencies of the direction of the annual wind-gust maxima were: North 1, North-west 22, West 10, South 1.

Over the periods 1841-79 and 1882-1943 the mean number of days per month with gales were as follows:—

July	less than 1
October	2
All other months	1

(A gale is said to occur when for any occasion of about 10 minutes the average wind is 39 m.p.h. or more. Gusts could be expected to reach a wind speed of at least 50% above that for the mean of a 10-minute period.)

III. SOILS

The soils of the area have been described by Nicolls (1958) as follows:—

"The leaching potential of the climate is high so that soils, other than young ones, are highly leached.

"On the broad limestone floor of the valley a deep yellow podsolic soil has developed. The accumulation of soil is due to the fact that the limestone is very impure. The classical soils of limestone—Terra Rossas and Rendzinas—apparently do not occur in the Florentine, presumably because of the wet environment. pH varies from 5.3 to 5.7.

"The soils developed on the highly siliceous rocks on Tim Shea and on the low ridges of silicified limestones (see I. Topography and Geology) are typical of those on similar parent materials elsewhere in Tasmania. They are sandy and gravelly, highly acid (ph 4.1-4.4), and have considerable accumulation of organic matter in the A and B horizons. The soils developed on the silicified limestone have yellow clay at a depth of several feet.

"There are large areas of young soils because of the presence of recent deposits. The two important ones are:—

(1) The Lawrence's Creek fluvio-glacial deposits, which fan out on the floor of the valley. These deposits were probably laid down during the late Pleistocene.

(2) The mantle of solifluction debris which presumably dates from the concluding stages of the late Pleistocene glaciation. This type of material is common in central and eastern Tasmania above 2,000 feet, but occasionally it may descend in ribbons to as low as 1,000 feet (Davies, 1958).

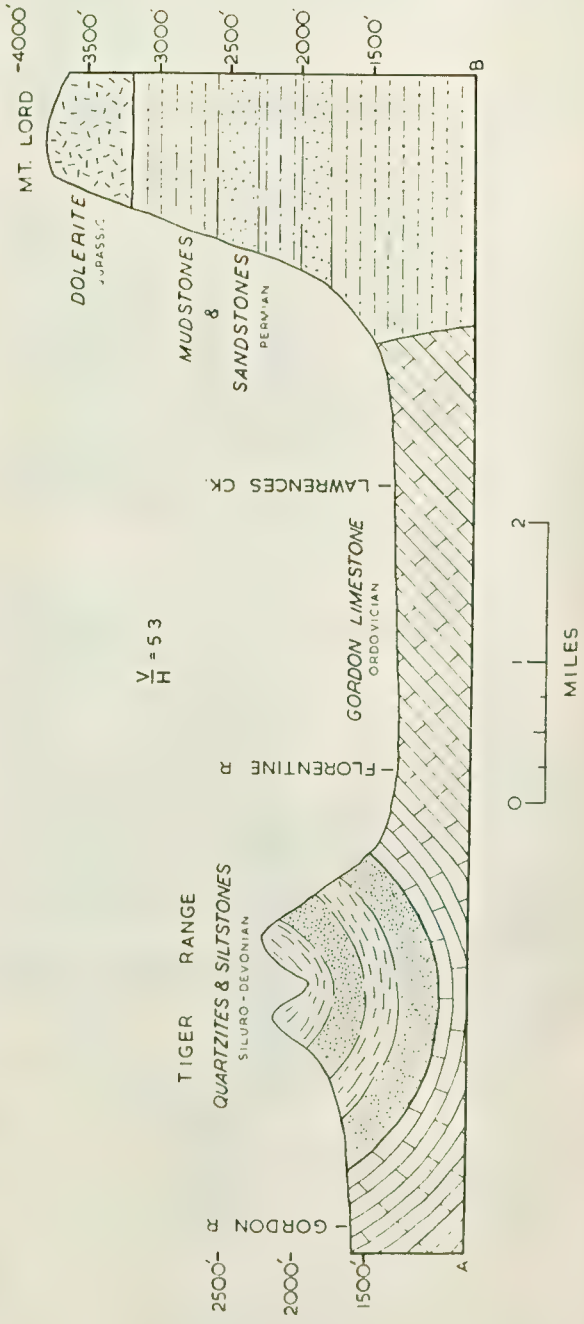

FIG. 1.3. Geological cross-section on an E.W. line from Gordon River to Mt. Lord. Location of section shown in Fig. 1.2 (*a*).

"On the fluvio-glacial deposits a brown loam has been developed which has an apparently uniform profile to a depth of 3-4 feet and overlies dolerite gravels. Internal drainage is free. Over wide area the solifluction deposits overlie the Permian mudstones and sandstones (Fig. 1.3) and essentially consist of unsorted dolerite boulders of all sizes in an earthy matrix. There is little differentiation in the soil profile, apparently due to limited downward movement of iron and clay. The solifluction deposits are probably important in that they bring weathering dolerite on to the rather sterile Permian sediments".

Sedgeland, wet scrub or poor-quality eucalypt forest occur on the soils derived from siliceous rocks or silicified limestone. The other soils support a forest of good quality.

In unburnt forest there is an accumulation of organic matter at the base of large *Nothofagus* and *Eucalyptus*, to a depth of 1-2 feet. This material is in the form of a cone and within a few yards the layer may be less than an inch thick. Beneath *Atherosperma* the litter layer is virtually absent, even at the base of the trees.

IV. FOREST TYPES

1. Nomenclature

(*a*) *Taxonomic.*

As the latest complete Tasmanian flora was compiled more than fifty years ago (Rodway, 1903), the names used have been taken from several sources.

(1) *Gymnosperms* and the *Polypetalae* (of Bentham & Hooker), except *Eucalyptus*, from Curtis (1956).

(2) *Eucalyptus*—Blakely, (1934).

(3) *Ferns*—Wakefield, (1957).

(4) *Other Tasmanian plants*—Rodway, (1903).

(5) For plants not covered above, the author's names are given in an appendix. As a general rule, eucalypts are referred to by their specific names only.

(*b*) *Ecological.*

The classification proposed by Beadle and Costin (1952) is used to the extent to which it is applicable. The eucalypt-rainforest mixtures would be called "wet sclerophyll forest" but in reality they do not conform to the definition of this type in several important respects, e.g., the scattered eucalypts which occur above the understory of rainforest sepcies do not have densely interlaced crowns. Accordingly, this type is labelled "Mixed Forest". Jacobs (1936) has suggested that the tender naked buds make interlacing impossible. Eucalypt crowns never interlace in the way that many other trees do. For want of a better term, all stands of eucalypts, other than those with a well developed understory of rainforest species, have been called "Eucalypt Forest". The term "sedgeland" (Jackson, 1958) is used for the more or less treeless vegetation which is found on shallow acid soils. It consists of a mixture of low shrubs of the families *Myrtaceae, Epacridaceae* and *Proteaceae* and sedge-like plants of the *Cyperaceae* and *Restionaceae*.

FIG. 1.4. Profile diagram of transect in temperate rainforest, Road 7, Florentine Valley. Transect 50 feet wide but *Dicksonia* shown for central 32 feet only.

2. Preliminary Note

Jackson (1958) has suggested that for S.E. Australia generally, rainfall requirements for the development of temperate rainforest are an annual fall of at least 50″ with a minimum of 2″ in each of the months of January, February and March. Other estimates of minimum annual rainfall for rainforest in Tasmania have been 50″ by Curtis and Somerville (1949) and nearly 60″ by Gilbert (1949). Fires have upset ecological succession in the region but it is apparent that at Maydena (49″) and Tarraleah (53″) a lowered fire-frequency would have allowed rainforest to have developed fairly generally.

In the central Florentine Valley the climax is temperate rainforest, except on some very acid soils of low fertility where the climax would be eucalypt forest or sedgeland.

Fire has been the major factor preventing the general attainment of climax vegetation. On soils of moderate to high fertility the particular frequency of fires has determined the point reached in the succession towards the climax. Thus:—

1. If an area remains unburnt for a single period of 350-400 years (life span of the main forest eucalypts) the climax condition is achieved.

2. If an area is burnt infrequently but with an interval between fires of less than 350 years, it remains under mixed forest. The forest is destroyed by each fire but the species present in the fully developed mixed forest regenerate immediately after the fire.

3. With a fire frequency of once or twice per century the mixed forest is replaced by eucalypt forest with an understory characterised by *Pomaderris*, *Olearia* and *Acacia* instead of climax rainforest species.

4. Still more frequent fires, perhaps at ten to twenty year intervals, will not only prevent eucalypt forest progressing to mixed forest but will maintain *obliqua* and *gigantea* at the expense of the much more fire-sensitive *regnans*.

5. There is evidence that very frequent fires were responsible in part for the maintenance of savannah-like conditions in the middle Florentine until perhaps 100-200 years ago.

On the soils of low fertility, much sedgeland would have progressed to wet scrub if not low eucalypt forest but for frequent fires. These are possible because of the inflammable nature of the vegetation and have occurred because the open sedgelands were routes of travel of the aboriginals and, later, white man.

With all forest types, freedom from fire—which means progression towards the climax—leads to floristic simplification. The ultimate in simplification is temperate rainforest, a condition unlikely to be attained on very poor soils. As soils improve, two main changes take place:—

1. Tree height increases; and
2. The floristics become simplified.

Neither aspect nor drainage are generally decisive in determining the distribution of forest types, although the development of sedgeland is favoured by impeded drainage on poor soils. Except on small flats along the Florentine River, drainage is good on the limestone floor of the valley.

FIG. 1.9. Profile diagram of old mixed forest, Road 10, Florentine Valley. Transect 50 feet wide but *Dicksonia* shown for central 32 feet only.

Fig. 15 Temperate rainforest near Companion River, N.W. Tasmania. Principally *Nothofagus cunninghamii* with *Atherosperma moschata*.

Fig. 1.10. Mixed forest, Florentine Road, upper Tyenna Valley. *Eucalyptus obliqua* with some *E. gigantea*. Understorey of *Nothofagus cunninghamii* and *Atherosperma moschata* (light coloured crowns).

Aspect has little direct influence in the distribution of the forest types. Rainforest and old mixed forest cover most of the westerly and north-westerly slopes of the Field West Range from Field West to Tim Shea because the middle Florentine is protected from fires from the west and north-west by the Tiger and Gordon Ranges. The main source of past fires has been in the vicinity of Dawson's Road and further north.

Elevation sets limits to the distribution of species but not to vegetation types. Thus *regnans* is not found above 2,000 feet, but mixed forest is common and dwarf rainforest is occasionally found to the limits of eucalypts at 4,000-4,200 feet.

3. Forest Types

The following forest types will be considered:—

(*a*) *Temperate Rainforest.*

This is an association of *Nothofagus cunninghamii* and *Atherosperma moschata*, in which other flowering plants are of rare occurrence except under special circumstances.

(*b*) *Mixed Forest.*

The mixed forest consists of eucalypts with an understory of rainforest species. In old stands the understory is not essentially different in structure or floristics from that of pure rainforest. In any one stand the eucalypts are of the same age ("even-aged").

(*c*) *Eucalypt Forest.*

(i) *On soils of moderate to high fertility.*

In these forests *Nothofagus* and *Atherosperma* play a minor role at present. The eucalypt forest will be dealt with as follows:—

(1) Areas affected by the 1934 or later fires;
(2) Areas which, until recently, carried savanah woodlands;
(3) Areas burnt probably 3-4 times in the last 200 years by fires of low intensity.

These are shown together as a blank area in Fig. 1.2 (*b*), marked "1934 fire". Within this area there is great variation in the eucalypt stands.

(2) *On soils of low fertility.*

Fairly extensive areas of poor eucalypt forest occur on siliceous soils on Tim Shea, and in the floor of the valley on the low ridges formed from silicified bands of limestone. These are indicated in Fig. 1.2 (*b*) as "Eucalypt forest—mixed ages".

(*d*) *Non-forested.*

The principal non-forested areas are found on the slopes of Tim Shea on conglomerate and quartzite—shown as "sedgeland" in Fig 1.2 (*b*). In addition, some very small treeless areas occur as remnants of the savannah of the middle Florentine.

A. Temperate Rainforest.

(*a*) *General.*

Temperate rainforest occupies large areas of the floor of the Florentine Valley to the north of Tim Shea and extends on to the steep slopes of the Field West Range from Wherrett's Look-out to Mt. Field West.

A feature of the forest, particularly on the lower slopes, is the small number of species present. Except for *Nothofagus* and *Atherosperma*, the counts of Spermatophytes are shown in Table 1.5 for five transects.

Table 1.5.—*Counts of Spermatophytes, Other than Nothofagus and Atherosperma on Transects in the Maydena District.*

Location	Size of Transect (ft.).	Species	No.
Road 7, Florentine	900 x 33	....	
Road 7, Florentine	250 x 30	..	
Road 10, Florentine	320 x 50	Pittosporum bicolor	1
5½m., Florentine Rd.	345 x 50	Pittosporum bicolor	1
Styx Valley	660 x 33	Olearia argophylla	1

In the above table the last three transects were in old mixed forests where the change to rainforest on the death of the eucalypts from old age, would not introduce new species. The transects may exaggerate the general position but it is clear that species other than *Nothofagus* and *Atherosperma* are not common. On good soils, species occasionally found are *Pittosporum bicolor, Coprosma billardieri, Clematis aristata* and *Aristotelia peduncularis*. Where the canopy of *Nothofagus* and *Atherosperma* is broken as is usually the case on poor soils, *Eucryphia lucida, Anodopetalum biglandulosum* and *Phyllocladus asplenifolius* (trees), together with *Anopterus glandulosus* and *Cenarrhenes nitida* (shrubs), may be locally frequent. An increase in the frequency of these species is fairly common on steep slopes at elevations above 1,500-2,000 feet. *Olearia argophylla* is not commonly found in rainforest or mixed forest. *Lyonsia straminea* has not been observed, the only liane found being an occasional *Clematis*.

(*b*) *Description of Transect.*

The profile of a transect in rainforest is given in Fig. 1.4. Although some trees on the 50-ft. wide transect could not be shown the only important omission is a dead *Nothofagus* 85 feet high and 15 feet in girth.

The upper stratum consists of *Nothofagus* which, in spite of deep, dense crowns, have a general appearance of senility. Some have dead tops with *Phymatodes diversifolium* growing on the main limbs and there are two standing dead trees. The *Nothofagus* canopy is not complete (Fig. 1.5), for large gaps occur. It is in the gaps that *Atherosperma* reaches its maximum development. The dimensions of the five largest *Nothofagus* were:—

	G.B.H.	Height.	Crown Spread.	Crown Depth.
Mean	16.5	125	40	80
Maximum	10	130	58	85

(Measurements in feet.)

Atherosperma has a total height of 80-100 feet, but does not develop a broad-topped crown as does *Nothofagus*. Also, the crown is more open and persists to lower levels. Small *Athersperma* occur throughout the transect in numbers far exceeding those of *Nothofagus*, which suggests that it is the

more shade-tolerant species. Large numbers of *Nothofagus* seed germinate but few seedlings survive beyond the cotyledonary stage. On nearby roadside clearings well established *Nothofagus* seedlings are present in large numbers.

The tree-fern *Dicksonia antarctica* forms a broken stratum at 8'-10'. Many of the plants are showing the effects of low light intensities (c. 1/100 of that in the open)—mature fronds are often only three feet long and the tops of the trunks are sharply tapered. The forest is very open near ground level.

There are few logs on the ground. *Atherosperma* is not durable and many *Nothofagus* die "on their feet" and rot away while still standing. Logs, fallen limbs and the ground (except under mature *Nothofagus*) are more or less completely covered with a layer of liverworts, mosses and lichens. The Bryophytes also grow on most of the tree and fern trunks, and commonly reach a height of 80'-90'. Of the epiphytic ferns, *Grammitis billardieri* occurs here and there on logs and trunks (sometimes to 80 feet), members of the *Hymenophyllaceae* occur on lower trunks, and *Phymatodes diversifolium* is found at high levels in the crowns of dead and dying *Nothofagus*.

In Table 1.6 is shown the distribution by girth-classes of the trees depicted in Fig. 1.4 (transect A) and those on a nearby transect (B).

(c) Regeneration in the Virgin Forest.

The distribution of the two species over the range of girth-classes is markedly different. For *Atherosperma* it shows that a state of continuous regeneration has existed in the past. Ring counts confirm that the small trees are young. Recruits to the upper girth-classes are available in numbers which would allow considerable losses to occur among the lower classes without causing a significant fall in numbers in the upper.

Large numbers of *Atherosperma* are not of seedling origin. Dozens of small shoots may come from low on the trunk of a single tree; many of these shoots will grow to more than 4' 3" high and a few will grow to maturity (usually only one, sometimes two or three from one parent). It is not uncommon for one or two of these shoots to have grown to 6-9 inches in diameter and 50-60 feet high before the parent stem dies.

Although adventitious shoots are quite common on the lower trunks of old *Nothofagus* they have not been seen to persist.

In Transect A there are fewer *Nothofagus* below than above 2 feet G.B.H. and there are no trees in the range 2-6 feet G.B.H. All the *Nothofagus* above 6 feet G.B.H. are old trees and most would be dead before any of those below 2 feet girth had reached maturity. In Transect B much the same position is revealed. There is only one *Nothofagus* between four feet and eight feet girth, and to replace the 24 decadent trees above 8 feet G.B.H. some recruits would have to come from trees less than 1 foot G.B.H. Gaps in the present *Nothofagus* canopy are occupied by *Atherosperma* and additional gaps will develop as the large *Nothofagus* die (probably in 50-100 years). Because of its advantage in numbers and distribution of young trees, *Atherosperma* is likely to occupy more and more of the site to the exclusion of *Nothofagus*.

But this may be only part of a cycle of varying success in the establishment of regeneration. From ring counts made in nearby areas, it seems probable that in this case the absence of the middle girth-classes of *Nothofagus* represents a gap of 200 years in successful regeneration. Jones (1956) reports a paucity of middle sizes in most of the emergent species in tropical rainforests in Southern Nigeria. The trees below 4 feet girth on transects A and B look young—this is indicated by the character of the fissuring of the bark, the amount of moss on the trunks and limbs, and the shape of the crown. By contrast the trees in the upper-girth classes look very old and some are nearly dead. On the basis of ring-counts made on nearby areas it is considered that the stand is at least 500 years old.

(d) Age Determination.

The age determinations of *Nothofagus* on nearby areas were made from counts of annual rings on stumps and logs of trees felled for saw logs. The older trees were very rotten at stump height (4-6 feet), but at 15 feet or so from the ground were generally sound enough for complete counts to be made. Radial increments were found to be very low, particularly during the last 100-200 years of the life of the tree. The mean number of rings per inch was 15.6 for all sections counted. Averages of 20 rings per inch were noted over the last 100-200 years of the life of some trees and many old trees had 40 rings per inch. Such trees have very rotten butts and their crowns contain some dead limbs. It is doubtful that they would live for more than another 50 years. Yet many such trees yield logs sound enough for milling.

TABLE 1.6.—*Number of Trees per Acre, by Girth-Classes on Two Transects in Temperate Rainforest Road 7, Florentine Valley.*

Transect.	Species.	Seedlings. 1'-4' 3"	Girth Breast-High—Feet										Total.
			0-0.5	0.5-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	>8	>1' G.B.H.
A 250' x 50'	*Nothofagus*	6	17	....	3	....	....	....	....	3	3	23	32
	Atherosperma	404	106	43	57	23	11	6	11	6	....	....	114
B 900' x 33'	*Nothofagus*	49	55		10	3	4	....	1	....	....	24	42
	Atherosperma	?	592		85	33	21	16	9	....	3	....	167

The highest count gave an age of 450 years and several gave about 400 years. Field counts are made with difficulty but it is clear from the age of old eucalypts still growing in some of the stands where the counts were made, that the ages of the *Nothofagus* are of the right order of magnitude. The relation between the age of the eucalypts and rainforest species in mixed forests will be discussed later. Although the greatest age attained by *Nothofagus* has not been established with certainty it is reasonable to assume that it is 450-500 years.

Atherosperma reaches little more than half the age of *Nothofagus*. Mr. A. B. Mount, of the Tasmanian Forestry Commission has informed me of a count of 250 years in the Styx Valley. In the Florentine, where the *Nothofagus* counts mentioned above were made, nine trees of *Atherosperma*, ranging in G.B.H. from 4′ 6″ to 7′ 5″, had counts of 180-240 years. No other trees were seen that were larger than seven feet G.B.H. but it would be surprising if there were not some older ones. However, it is certain that the *Atherosperma* which germinated at the same time as the old *Nothofagus* have died and rotted away and that *Atherosperma* has been in a continuous process of regeneration and death. Once decadent, *Atherosperma* dies quickly and rapidly rots so that few dead and dying trees remain in the stand. One *Atherosperma* felled for saw logs was typical. The tree was six feet in girth and 102 feet high. Foliose and bearded lichens, mosses and ferns, grew on the branches and trunk in great abundance, even more than 80 feet above the ground. The centre of the stump was rotten for a radius of three inches and outside this 180 rings could be counted so that the tree was about 225 years old and would probably have deteriorated rapidly in the next 25 years. At 3′ 6″ from the ground a side shoot with a diameter of 7.5 inches was found to be 100-110 years old. When this shoot first appeared the parent tree must have been 80 feet or so high.

From measurements made in several of the Florentine it appears that *Nothofagus* does not often exceed 120-130 feet in height, even though a height of 115-120 feet may be reached in less than 150 years. Thereafter the crown spreads and becomes more dense. *Atherosperma* can reach 100 feet in height in 150 years.

(e) *Litter Layer.*

Near old trees of *Nothofagus* the mineral soil may be covered with litter to a depth of a foot or so, although usually this layer thins to 1-3 inches within a few yards of the tree. When the stand consists mainly of *Atherosperma* the litter layers are very thin and the mineral soil can be exposed with a rake of the fingers. Quite often the litter layer is virtually absent. This is remarkable under conditions of full canopy, cool temperature and moderately heavy rainfall. It is one of several features of *Atherosperma* worthy of investigation.

Fairly extensive stands of *Atherosperma* occur in which *Dicksonia* is often the only other plant besides liverworts, mosses and lichens. These relatively pure stands exhibit some peculiar features which will be discussed later (see V. Development of the Climax Types).

B. Mixed Forest.

In order of decreasing abundance, the ecualypt species are *regnans, gigantea, obliqua, viminalis* and *ovata*. As is usual in Tasmania, *gigantea* is the most important forest tree above 1,800-2,000 feet, but in the Florentine it is also not uncommon on the floor of the valley (below 1,500 feet). Below 2,000 feet the relative ecological position of *regnans, obliqua* and *gigantea* requires considerable investigation. In general, the forest consists of a series of fairly extensive even-aged stands. The distribution of ages is quite irregular, there being large areas of the following (as in 1957)—23, 120, 150, 205, 315 and 400 plus years. Other ages have been reported but they probably occupy small areas. As will be discussed later, the large even-aged areas must have arisen from past fires, for with a fire-tender species like *regnans*, survival, even of adult trees, is unusual except at the dying margin of a fire. With more fire-resistant eucalypts such as *obliqua* many trees may recover after fires so that there is often an intimate mixture of many ages, particularly on poor sites.

(a) *Mixed Forests* (175-400 *years*). Fig. 1.2.

This forest consists of very large eucalypts (*regnans, obliqua,* or *gigantea*) with a mean density often less than five trees per acre, growing over a fully-developed understory of rainforest species. The structure of the understory differs little from that of pure rainforest. At ground level the light intensity is as low as in rainforest—c. 1/100 of that in the open.

Measurements have been made on three transects.

Transect 1, *Road* 10, *Florentine Valley* (Fig. 1.9).

Comparing the appearance of the eucalypts with stands of known age, it was estimated that this stand was over 300 pears old. All the eucalypts were apparently of the same age.

The number of *regnans* (11 per acre) is high for old mixed forest.

The four *regnans* on the transect had the following dimensions:—

	Mean.	Maximum.
Girth-breast-high	29.5′	42.0′
Total height....	220′	250′
Crown spread	40′	55′
Crown depth	145′	180′

Crowns are stag-headed.

As in all mixed forests, eucalypt seedlings, saplings, or poles are absent.

The dominant trees of the understory are *Nothofagus*. In Table 1.7 the five largest *Nothofagus* and *Atherosperma* on this transect are compared with those on the transect described in rainforest.

TABLE 1.7.—*Comparison of the Five Largest Nothofagus and Atherosperma in Rainforest and Mixed Forest. Measurements in Feet.*

Species. Transect.	G.B.H. Mean.	G.B.H. Max.	Total Height. Mean.	Total Height. Max.	Crown Spread. Mean.	Crown Spread. Max.	Crown Depth. Mean.	Crown Depth. Max.
Nothofagus—								
Rainforest	16.5	19.0	125	130	40	58	80	85
Mixed Forest	12.5	21.0	100	115	35	50	75	100
Atherosperma—								
Rainforest	5.7	6.5	95	100	30	35	75	80
Mixed Forest	5.5	8 75	90	95	25	25	70	80

On the basis of the five largest trees (rate 14 per acre) the pure rainforest is not markedly different from the understory in the old mixed forest except that the trees of *Nothofagus* in the mixed forest are smaller. As the samples are small and the site differences potentially so large, these size differences need not be significant.

The distribution of the trees by girth-classes is shown in Table 1.8.

Compared with the transect in pure rainforest (Table 1.6) the mixed forest carries many more *Nothofagus* over one foot G.B.H. (with the increase in numbers mainly in the smaller girth-classes). Furthermore. there is some representation in all classes. The contrast between *Nothofagus* and *Atherosperma* in the distribution of stems by girth-classes is of the same pattern in both cases, *Atherosperma* exhibiting a relative predominance of seedlings, *Nothofagus* of adults.

Transect 2, *Styx Valley.*

The result of an assessment, on a 10 chain x ½ chain transect in old mixed forests in the Styx Valley is shown in Table 1.9.

The age of the forest is not known but, although the eucalypts were smaller (mean G.B.H. 20 feet), they were probably about the same age as those of the Road 10 transect—over 300 years. The site of the Styx transect was not ideal for *regnans*, being on a steep ridge which would probably carry *obliqua* if the rainfall were somewhat lower.

Bearing in mind that the sample is small (½ acre), the figures suggest that successful regeneration of *Nothofagus* has not been continuous. The future status of *Atherosperma* is clear enough but this is not the case with *Nothofagus.*

Transect 3, *Upper Tyenna Valley* (5½ *Mile, Florentine Road*). (*Figs.* 1.10 *and* 1.11.)

The site of this transect was at first considered to be poorer than Road 10 for the following reasons:—

1. *regnans* is replaced by *gigantea* and *obliqua*, the latter being considered to indicate poorer sites.
2. The canopy of the understory here is much more broken than in Road 10.

TABLE 1.8.—*Number of Trees per Acre, by Girth-Classes on Transect in Old Mixed Forest, Road* 10, *Florentine Valley. Transect* 320 x 50 *feet.*

Species.	Seedlings. 1′-4′ 3″	Girth Breast High—Feet. 0-0.5	0.5-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	>8	Total. >1′ G.B.H.
E. regnans	....	....	....	....	....	....	....	....	....	....	11	11
Nothofagus	22	71	8	24	3	11	3	3	5	3	14	66
Atherosperma	327	193	120	57	24	22	8	3	....	....	3	117
Pittosporum	....	....	....	3	....	....	....	....	....	....	....	3

TABLE 1.9.—*Number of Trees per Acre, by Girth-Classes, on Transect in Old Mixed Forest. Styx Valley. Transect* 660 x 33 *feet.*

Species.	Seedlings. 1′-4′ 3″	Girth Breast High—Feet. 0-0.5	0.5-1	1-2	2-3	3-4	4-5	5-6	6-7	718	>8	Total. >1′ G.B.H.
E. regnans	....	....	....	....	....	....	....	....	....	....	6	6
Nothofagus	6	106	20	16	....	...	8	2	4	2	8	40
Atherosperma	176	720	164	114	50	28	10	6	....	....	....	208
Olearia	....	....	....	2	....	....	....	....	....	....	....	2

3. *Eucryphia* and *Anodopetalum* are common in the vicinity but just failed to get within the limits of the transect. These are two of several species usually regarded as indicative of fairly poor sites.

However, tree height is recognized as a good index of site quality, which basically is the capacity of the site to produce wood. In this case the eucalypts have grown to 250 feet and *Nothofagus* to 130 feet. Such heights indicate a site of high quality, and are of the same order as those of the Road 10 area. It must be concluded that the broken canopy of the *Nothofagus* on the transect in the Tyenna Valley had resulted from an initially poor stocking rather than from a poor site.

The number of trees per acre is shown in Table 1.10.

presumably because of competition for room in the stand. Understory trees of *Nothofagus* and *Atherosperma* occur throughout such stands and, where the eucalypts are locally less dense, may reach heights of 120 and 100 feet respectively in 150 years. The canopy of the understory is not complete, with the crowns of *Nothofagus* just becoming flat-topped but still relatively narrow. During the next 50 years, as a few eucalypts die, the understory will gradually assume the appearance of a rainforest with eucalypts towering above it.

As with the older mixed forests, the eucalypts are in even-aged stands, i.e., there is a complete absence of eucalypt seedlings and saplings.

C. Eucalypt Forest.

This includes all stands of eucalypts in which rainforest species at present play a minor role.

Table 1.10.—*Number of Trees per Acre, by Girth-Classes, on Transect in Old Mixed Forest, Tyenna Valley, 5½ Mile, Florentine Road. Transect* 345 x 50 *feet.*

Species.	Seedlings.	Girth Breast High—Feet.									Total.
	1′-4′ 3″	0-0.5	0.5-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	>8	>1′ G.B.H.
Nothofagus	....	....	....	....	....	....	....	....	....	....	13	13
Atherosperma	33	28	10	3	3	....	3	3	....	....	15	30
Pittosporum	397	126	28	45	15	20	25	5	3	....	....	113
*E. obliqua**	....	....	....	3	....	....	....	....	....	....	....	3

* Fallen twigs indicate that some of the trees were *gigantea*, but the standing trees could not be separately identified.

The number of eucalypts was above average for the surrounding forest, for which 5-10 per acre is a reasonable estimate.

Compared with Road 10 there are only half as many *Nothofagus* above one foot G.B.H. and far fewer small trees and seedlings. The 33 seedlings of *Nothofagus* shown in Table 1.10 were not dispersed throughout the transect but on the soil among the roots of one fallen dead tree, and almost all the small *Atherosperma* were suckers on the butts of standing trees. The broken canopy of the understory had enabled *Dicksonia* and other ferns to grow vigorously and conditions approached those to be found in a fern gully where seedlings of tree species became established only with difficulty (Fig. 1.12).

(*b*) *Young Mixed Forests.*

Young mixed forests (age 100-150 years) occur principally towards the northern end of the study area (Fig. 1.2 (*b*)) and to the north and northwest of it. Those within the study area generally comprise *regnans* (height 250 feet) with an understory of *Nothofagus* (to 120 feet), *Athersperma* (to 100 feet) and very occasional *Acacia melanoxylon* and *Pittosporum. Comprosma billardieri* and *Clematis* are occasionally found.

Officers of the Forestry Commission and Australian Newsprint Mills have made counts of the number of live eucalypts on several one-acre assessment plots in young mixed forest. Thirty *regnans* constitute full-stocking in 150-year-old stands. Such fully-stocked stands contain some eucalypts which have recently died or are about to die

(*a*) *Stands on Soils of Moderate to High Fertility.*

(i) Mixed Forest Affected by the 1934 or Later Fires.

From counts of annual rings it appears that no widespread fires occurred between the 1840's and 1934, when a fire spread from the vicinity of Dawsons Road southwards for eight miles. Its southward spread was obviously assisted by the presence of large areas on the floor of the valley which had recently been savannah and by inflammable vegetation on the series of low ridges of silicified limestone. Fires which burn through mixed forest usually kill all the eucalypts, particularly where the eucalypt component is the fire-sensitive *regnans*. Although a few eucalypts may survive, trees of the understory rarely escape destruction. The general pattern of fire behaviour will be discussed in a later section (V. The role of fire in forest succession).

Mixed Forest Completely Destroyed by the 1934 *Fire.*

The resultant stand could be classified as young mixed forest for the essential components are present, both eucalypt and rainforest species. However, the rainforest species are of little significance in the present stand (just over 20 years old) and several seral species are present: *Acacia dealbata, Olearia argophylla,* perhaps a few *Pomaderris apetala* and the last traces of fireweed species such as *Senecio australis* and *Erechthites prenathoides.* Small trees and shrubs, which are rare in mixed forest, are not uncommon, *e.g., Coprosma billardieri, Pittosporum bicolor, Clematis aristata.* Depending on the density of the eucalypt regeneration and the locality, a fern stratum 3-4 feet high and of

greatly varying density and continuity is usually present. The most common species are *Histiop teris incisa, Polystichum proliferum, Hypolepis rugosula* and *Blechnum procerum.* This fern stratum will practically disappear if the canopy of rainforest species becomes more or less complete or the stratum will become fairly general, with locally dense patches, if this canopy remains broken.

Few measurement have been made in the stands of eucalypt regrowth resulting from destruction of mixed forest by the 1934 fire. Early growth of *Nothofagus* and more particularly *Atherosperma* may be so slow (often 2-6 inches in height in three years) that ring counts may falsely indicate that the rainforest species are younger than the eucalypts. Thus in a 22-year-old stand of *regnans, Nothofagus* gave counts of 18-20 years. In a stand of *gigantea,* ring-counts of *gigantea* and *Nothofagus* were the same—22 years. The mean dominant heights in the 22-year-old stad were *regnans* 80 feet, *Nothofagus* 25-30 feet and *Atherosperma* smaller.

Mixed Forest Destroyed by Fire since 1934.

The areas included here are those logged by Australian Newsprint Mills since about 1950 and on which logging slash has been burnt. Conditions are somewhat artificial, but in many small patches only slightly so. Large numbers of quadrats have been examined and the general rule is that there is fairly immediate and coincident germination of all species which are likely to be present from year 1 to year 400 or so when the last eucalypts die of old age and the site is left occupied by rainforest.

Mixed Forest Burnt in 1934 *and again in* 1948.

By fire or axe man can put the succession back to year 1 but, should a second disturbance come before all the tree-species are producing seed, a different successional pattern would follow.

An area of mixed forest which was burnt in 1934 was burnt over again in 1948. The second fire killed the rainforest species—the incipient understory—so that now there is only a fern stratum.

In places the 1948 fire was hot enough to kill all the 14-year-old eucalypts, and scattered regeneration followed the fire. The only survivors of the pre-1948 understory are coppice shoots of *Nothofagus* and *Atherosperma,* with the latter far more abundant.

The second fire has drastically reduced the stocking of tree-species and allowed the development of the dense fern stratum, about four feet in height. Tree seedlings growing below the level of this stratum will emerge slowly and suffer heavy losses. In their present condition ferns allow few new seedlings to become established and are likely to do so for many decades where tree-species are entirely absent. As tree seedlings develop, modification of the fern stratum will allow new shade-tolerant seedlings to become established and progression to more normal forest conditions would then proceed at a much faster rate.

(ii) Areas Recently Occupied by Tree and Shrub Savannah.

The occurrence in the recent past of tree and shrub savannah over several hundred acres in the central Florentine was first reported by Jackson (1956). Only a brief description can be given here of the eucalypt stands on these areas.

FIG. 1.11. Profile diagram of transect in mixed forest, 5½ m., Florentine Road, upper Tyenna Valley. Transect 50 feet wide but *Dicksonia* shown for ectnral 32 feet only.

It is probable that the savannah was made up of two sub-associations:

1. *Drimys aromatica—Hakea microcarpa*: *Poa caespitosa* shrub savannah; and
2. *E. ovata—E. viminalis—Acacia dealbata*: *Poa caespitosa* tree savannah.

It appears that physiography and climate would have allowed the area to be occupied by mixed forest or rainforest. Two factors which may have been responsible for the maintenance until recent times of savannah conditions are as follows:—

1. Repeated burning. Although the savannah is now rapidly progressing towards closed forest, the area is still attractive to wallabies and other marsupials. Under savannah conditions native animals would have been even more plentiful and the area attractive to the aboriginals who used fire freely both to hunt game and to attract it to the fresh plant-shoots which follow fires.

2. Most of the area appears to be associated with the deepest sheets of the unconsolidated material referred to under "Geology". Water does not lie in the bottom of pits opened in these deposits for road-surfacing material and the deposits overlie cavernous limestone. It is probable that the water-holding capacity of the material is very poor.

The replacement of the savannah by eucalypt forest is probably the result of an increase in rainfall with an attendant decrease in fire frequency. The disappearance of the aboriginals 130 years ago may have resulted in a lower frequency of fires but, as many of the eucalypts are more than 200 years old, the change to eucalypt forest commenced before white man settled in Tasmania. A few small treeless patches are all that remain of the shrub savannah, *Hakea microcarpa* surviving with difficulty, whilst most other plants are smothered by bracken. Only a few tussocks of *Poa* and Cyperaceous species have survived except in a few small areas where the winter water-table is at ground level. Here *Poa caespitosa* is present as large hummocks.

In the succession to mixed forest, the order of appearance of the eucalypts is *ovata*, *viminalis* and *regnans*, with *Acacia dealbata* present throughout the succession, and sometimes the pioneer tree-species ahead of *ovata*. The species of the shrub-savannah do not survive for very long in the eucalypt forest with the exception of *Drimys*, which may build up to a continuous stratum, 15-20 feet high in the *ovata-viminalis* association. Thereafter it diminishes in frequency to become rare in mixed forest.

Acacia melanoxylon, *Olearia argophylla*, *Pomaderis apetala*, *Pittosporum bicolor*, *Coprosma billardieri* and *Phyllocladus asplenifolius* reach their peak frequency with the advent of *regnans*, but they are usually scattered trees of park-like habit, i.e., they have deep, very wide crowns. A few *Atherosperma* appear but *Nothofagus* is rare.

In the *regnans-viminalis* association the *viminalis* are very large trees of good form. Without disturbance of the site it is assumed that this association would change to pure *regnans*, because *regnans* with its faster rate of growth would suppress *viminalis* in most spots suitable for regeneration. It is possible that the understory will develop quickly enough to prevent eucalypt regeneration. However, part of the *regnans-viminalis* association was partially burnt by the 1934 fire and many more *regnans* than *viminalis* were killed. The resulting eucalypt regeneration consists of 50-feet saplings of *regnans* with 6-feet *viminalis* as part of a discontinuous stratum of shrubs. The shrub layer is quite different from that in mixed forest burnt in 1934, *Nothofagus* and *Atherosperma* being viraually absent. The commonest shrubs and tree seedlings of this forest are rare in mixed forest. They are *Drimys*, *Acacia dealbata*, *Acacia melanoxylon*, *Phyllocladus*, *Coprosma*, *Zieria arborescens*, *Olearia argophylla* and *Pomaderris*. Several Epacridaceous species are present and one, *Astroloma humifusum* is quite alien to forests.

The area once covered by savannah has been important because it provided an easy path for fires along the floor of the valley.

(iii) Areas Burnt Three to Four Times in the Last One Hundred Yearss by Fires of Low Intensity.

The stands on these areas have arisen because of the abortive effort at agriculture at Dawson's Road ("The Settlement"). Dawson's Road was built in 1847 as the beginning of a road link (uncompleted) to the West Coast. The first blocks of The Settlement were selected in 1904 and a start made in the following year to clear several hundred acres of mixed forest by felling, ringbarking and burning. By the early 1930's much of the cleared land was being overrun by bracken and scrub and attempts were made to halt this invasion with fire. Many fires spread into adjoining mixed-forest and greatly modified it. The eucalypt component became of mixed age and the simple *Nothofagus-Atherosperma* understory was largely replaced by *Acacia dealbata*, *Olearia argophylla* and *Pomaderris* with a few *Acacia melanoxylon*. Regeneration of *Atherosperma* occurred but, except for occasional trees, not of *Nothofagus*.

Even though *Atherosperma* occurs through the whole stand, and is not confined to gullies, the structure and floristics in these areas resemble that of wet sclerophyll forest in the 40-50" rainfall zone. It is similar to much *regnans* forest in Victoria. At Wallaby Creek, Ashton (1956—unpublished thesis) found the understory of *Pomaderris*, *Olearia* and *Acacia* (dealbata) was commonly 40 years of age and he had to search carefully to find one that was older (80 years). Unless further fires occur it seems that no further regeneration of eucalypts will occur in the Dawson's Road stands and that the sub-climax would be temperate rainforest with a broken canopy in which there would be a marked increase in the frequency of usually occasional species such as *Acacia melanoxylon*, *Pittosporum* and *Olearia argophylla* and a fairly complete stratum of tree-ferns (*Dicksonia*).

(*b*) *Stands on Soils of Low Fertility* (Fig. 1.2 (*b*)—Eucalypt forest of mixed age.)

Geographically there are two main areas, the more extensive at Tim Shea on conglomerates and quartzites and the other in the floor of the valley

on low quartzitic ridges running parallel to the Florentine River on its eastern side. The soils are shallow and very acid.

Eucalyptus simmondsii as on similar soils elsewhere in Tasmania where the rainfall exceeds 60 inches or so, occurs in fairly open stands with a relatively rich small tree and shrub stratum in which the families *Myrtaceae, Epacridaceae* and *Proteaceae* are strongly represented. The mature height of *simmondsii* may be as low as 40 feet.

The stands have been greatly modified by frequent fires. There is an intimate mixture of eucalypts of many ages and the shrub layer is usually young and, depending on the time since the last fire, also dense.

With an increase in soil fertility, *obliqua* and *gigantea* may occur with *simmondsii*. Tree height increases and understory trees are more numerous. With a further increase in soil fertility, shrubs are generally mesomorphic instead of generally xeromorphic and *simmondsii* goes out and *regnans* comes in.

D. Treeless Areas.

Except for a few small remnants of shrub savannah in the middle Florentine, together with rock and scree slopes of the Field West Range, treeless areas are confined to fairly extensive areas of poor, acid soils developed on the conglomerates and quartzites of Tim Shea ("Sedgeland"—Fig. 1.2 (*b*)). Around the foot of the mountain a few, very poorly drained flats probably constitute the only edaphic climax for *Mesomelaena* sedgeland. Elsewhere sedgeland and wet scrub have been maintained by frequent burning.

On the West Coast, freedom from fires would allow such areas of wet scrub to proceed through the stages of eucalypt forest and mixed forest to rainforest (Jackson, 1958), but on Tim Shea it is doubtful whether the succession would go beyond the mixed-forest stage, even if fires were excluded, because the rainfall is probably too low (just above 60 inches) for the maintenance of rainforest on such poor, shallow soils.

E. Summary.

The changes in plant association and floristics with changes in soil fertility and fire frequency are summarised in Table 1.11. The table has been divided into four fertility-gradings x four fire-frequencies, in order to illustrate the changes more clearly. The cells are certainly not of equal "dimensions," neither are the trends in ordered lines.

Eucryphia is included with caution. It is fairly common in the upper Tyenna Valley but not in the Florentnie Valley below 2,000 feet. The genera are arranged in a subjective order of importance.

Shrub and tree savannah are essentially of the past. Fire frequency would have to alter radically to enable eucalypt forest to develop on Tim Shea on soils derived from conglomerates and quartzites. For this reason the forest type to be found on soils of very low soil-fertility, given very low fire-frequency, is labelled "Future" in the table.

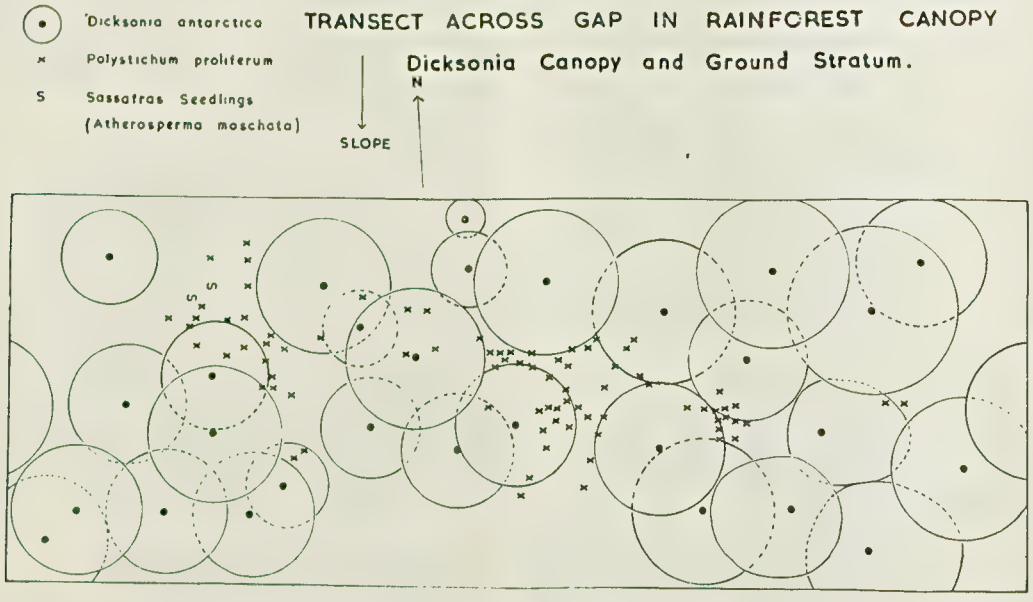

Fig. 1.12. Transect in forest depicted in Fig. 1.11. Plot 32 feet x 81 feet.

TABLE 1.11.—*Changes in Plant Associations and Floristics according to Changes in Soil Fertility and Fire Frequency in the Florentine Valley.*

Fire Frequency.	Soil Fertility. High ——> Low			
Low	Rainforest *Nothofagus* *Atherosperma* *Dicksonia*	Rainforest *Nothofagus* *Atherosperma* *Pittosporum* *(Eucryphia)* *Aristotelia* *Clematis* *Dicksonia*	Rainforest *Nothofagus* *Atherosperma* *Phyllocladus* *Anodopetalum* *(Eucryphia)* *Anopterus* *Cenarrhenes*	(Future) Mixed Forest. *Eucalyptus simmondsii* *Nothofagus* *Phyllocladus* *Leptospermum* *Anodopetalum* *Atherosperma* *Agastachys* *Cenarrhenes*
	Mixed Forest. *Eucalyptus—* *regnans* *obliqua* *gigantea* *Nothofagus* *Atherosperma* *Dicksonia*	Mixed Forest. *Eucalyptus—* *obliqua* *gigantea* *regnans* *Nothofagus* *Atherosperma* *Acacia melanoxylon* *Pittosporum* *(Eucryphia)* *Aristotelia* *Clematis* *Dicksonia*	Mixed Forest. *Eucalyptus—* *obliqua* *gigantea* *simmondsii* *Nothofagus* *Phyllocladus* *Anodopetalum* *Leptospermum* *Atherosperma* *Cenarrhenes* *Anopterus*	Eucalypt Forest. *Eucalyptus simmondsii* *Nothofagus* *Phyllocladus* *Anodopetalum* *Cenarrhenes* *Anopterus* *Leptospermum* *Monotoca* *Bauera*
Increasing	Eucalypt Forest. *Eucalyptus—* *obliqua* *gigantea* *regnans* *Pomaderris* *Olearia* *Acacia—* *dealbata* *melanoxylon* *Atherosperma* *Nothofagus* *Dicksonia*	Eucalypt Forest. *Eucalyptus—* *obliqua* *gigantea* *Pomaderris* *Olearia* *Acacia dealbata* *Phebalium*	Eucalypt Forest. *Eucalyptus—* *obliqua* *gigantea* *simmondsii* *Acacia—* *dealbata* *mucronata* *Leptospermum* *Banksia* *Gahnia* *Bauera*	Eucalypt Forest or Wet Scrub. *Eucalyptus simmondsii* *Acacia mucronata* *Leptospermum* *Melaleuca* *Banksia* *Agastachys* *Sprengelia* *Monotoca*
High	(Past) Tree Savannah. *Eucalyptus—* *ovata* *viminalis* *Drimys* *Hakea* *Acacia dealbata* *Coprosma* *Epacridaceae* *Poa*	(Past) Shrub Savannah. *Drimys* *Hakea* *Coprosma* *Epacridaceae* *Poa* *Eucalyptus ovata* (scattered)	Wet Scrub. *Leptospermum* *Melaleuca* *Banksia* *Acacia mucronata* *Agastachys* *Gahnia* *Bauera* *Eucalyptus simmondsii* (scattered)	Sedgeland or Wet Scrub. *Mesomelaena* *Melaleuca* *Leptospermum* *Restionaceae* *Sprengelia* *Banksia* *Agastachys* *Eucalyptus simmondsii* (scattered)

V. The Role of Fire in Forest Succession.

1. *Evidence of Fires.*

The presence of areas of several thousand acres of even-aged eucalypt forest is in itself strong and perhaps sufficient evidence that widespread fires have occurred in the Florentine during recent centuries. In Tasmania the general windthrow of trees in a stand is rare except over very small areas. It is thus hard to conceive of any agent other than fire being responsible for the large areas of even-aged forest. Over several thousand acres the eucalypts and the largest trees of the understorey species are all 150 years old. Similarly, there are stands of 400 plus, 315, 205, 120 and 23 years old (in 1957). The 23-year-old stands are widespread in western and southern Tasmania and arose from the devastating fires of January-February, 1934.

In all stands charcoal is readily found on the surface of the mineral soil after removal of the litter layer. Charcoal is usually absent on the trunks of fire-killed trees of species such as *regnans*. Few *regnans* survive a fire, so that burnt-out butts with a lining of charcoal are not produced. The cambium of *regnans* is killed but the bark is rarely burnt from the tree, so that when the bark is shed a clean skeleton remains.

2. *Cause of Fires.*

The Tasmanian aboriginal used fire freely (Jackson, 1958) and there is ample evidence that in his nomadic existence he moved inland from the coast in the summertime. Stone implements have been found on the mountain country to the east of the Field West Range. As lightning-storms in Tasmania are usually wet, there are few authentic records that lightning has caused forest fires (Gilbert, 1949), although single trees may be set alight. In over 20 years association with forest fire-control in Tasmania, I know of only two cases of forest fires spreading from lightning strikes. One was in the Florentine Valley!

Only under conditions of high fire-danger can a fire burn over several thousand acres of virgin forest of the type found in the Florentine Valley. The pre-requisites are a period of several weeks with little rain culminating in one or two days of high temperature, low atmospheric humidity and strong wind. Before 1800 the aboriginal probably started most of the fires. Since 1800, white man has been responsible. Mixed forest will be perpetuated if burnt before the eucalypts die of old age, i.e., if burnt at least once in 350-400 years. Difficult as it may be to burn mixed forest, it is reasonable to assume that during a period of 350 years, fire conditions will arise which are at least as severe as white man has experienced during the last 150 years.

3. *Creation by Wild Fire of Conditions Favourable for Eucalypt Regeneration.*

From investigations made into the factors affecting eucalypt regeneration in areas of high rainfall in Tasmania, it is clear that wild fire creates a situation in virgin, mixed forests which is favourable to eucalypt regeneration. The favourable circumstances would appear to be:—

(*a*) The understorey is destroyed.
(*b*) The forest floor becomes fully lit.
(*c*) The litter layer is destroyed.
(*d*) Some eucalypt seed is destroyed but large numbers of capsules survive on the trees and there is a heavy fall of seed soon after the fire.
(*e*) There is a reduction in the number of insects which harvest eucalypt seed.
(*f*) Extreme fire-danger develops under the influence of intense Southern Ocean depressions, and good rains usually fall with the passage of the cold front associated with these depressions.
(*g*) Browsing marsupials (principally wallabies) destroy large numbers of eucalypt seedlings and cause a growth check to many more. Openings in the forest are attractive to browsing marsupials but a very large opening created by wild fire would be favourable to seedlings, particularly as the density of the population of browsing animals is low in the surrounding virgin forest. The eucalypt seedlings gain an advantage by weight of numbers and area.

4. *Fire Behaviour.*

Eucalyptus regnans, Nothofagus, and *Atherosperma* are not fire resistant, so that fires usually kill all the trees and another even-aged stand develops. However, along fire edges and also scattered within the burn, two-aged stands may occur. The old stand is represented only by eucalypts. Unless conditions are exceptional, forest fires do most of their damage between mid-morning and dark. Between midnight and dawn fires advance slowly and sometimes stop running. During the period between late evening to mid-morning the rainforest understory may be killed, but under these conditions only a few of the much taller, relatively more fire-resistant *regnans*. The same thing occurs where fires die out as rain sets in or in places protected by their topographic position.

5. *Regeneration of Eucalypts in the Absence of Fires.*

Many reports have been investigated of eucalypt stands of mixed ages in the Florentine and Styx Valleys which have not been caused by fire, i.e., cases where eucalypt regeneration was believed to have become established in mixed forest without disturbance of the stand by fire. In all cases except one it was possible to demonstrate that the younger age-class had resulted from fire. The exception is worth recording because it depended on a set of circumstanuces likely to recur only very occasionally and so of no importance in the maintenance of eucalypts in mixed forests. A large *regnans* had fallen across a steep slope and then skidded sideways down a log lying on the ground so that about a tenth of an acre was cleared and in the clearing there was a dense 3-4 feet layer of ferns, three *Acacia dealbata* saplings and one *regnans* sapling.

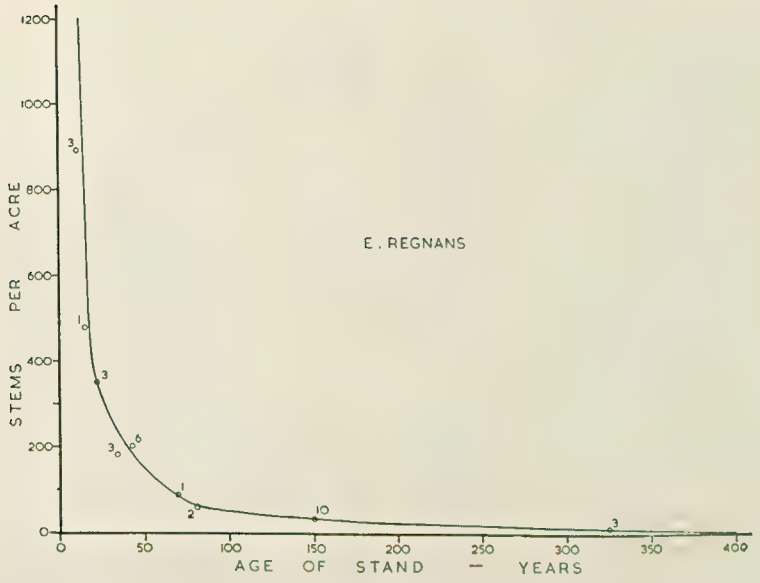

FIG. 1.15. Age--number of stems relationship for *E. regnans*. Information from plots established by Forestry and Timber Bureau (3), Forestry Commission (26), and Gilbert (3), in central and S. Tasmania. Plot sizes varied from ¼ acre for young stand to 1 acre for old stands. In three youngest plots, stems (numerous) less than 2½-in. diameter not included; on next oldest, stems (many) less than 12-in. girth, not included.

Fire is not essential for the re-establishment of eucalypts in all circumstances. Jarrett and Petrie (1929), in dealing with "Pyric Succession" in the Black Spur region of Victoria, stated that some *Eucalyptus* seed, on the ground before the fire, will escape destruction and that the fire or ashes from the fire stimulates germination or else "removes some previously operating inhibiting agent". Observations and sowing-trials in the Florentine do not support these conclusions. Eucalypt seed will germinate beneath the canopy of an undisturbed rainforest understory and if the litter layer is removed germination is improved. There is, however, no survival beyond the cotyledon stage.

Disturbance of the understory is an absolute essential for the successful establishment of eucalypt regeneration. However, removal of the understory and many other physical effects of fire can be achieved without fire. Regeneration is usually dense along the sides of roads in a forest. Clearing for road construction removes the understory and bares the mineral soil. Adequate seed is usually available from nearby standing trees. If all the eucalypts are felled on a logged area, regeneration is usually successful if the slash is not burnt, but unsuccessful if the slash, which contains the immediately available seed, is burnt. Replicated sowing trials on various types of seed-bed (in the forest) at various times and with various amounts of seed suggest that the physical effects of the removal of the understory by fire, of the destruction of deep litter and the sudden release of large amounts of seed from standing trees are the factors which cause the usually prolific crops of seedlings which follow fires.

Wild fires have been responsible for the continued existence of *Eucalyptus* in large areas of mixed forests. It is clear that fires of similar intensity and extent cannot form part of a planned system of regeneration of *Eucalyptus*. Apart from the risks involved, conditions on a cut-over area are markedly different from those in virgin forest. The logging slash provides fuel for an intense ground fire which destroys the seed in or shed from the capsules on the heads of the felled trees. In virgin forest these capsules would be on standing trees and much seed in them would survive fire.

Similar conclusions have been drawn elsewhere. Thus many of the stands of Douglas fir (*Pseudotsuga taxifolia*) on the Pacific Coast of North America owe their continued existence to past fires (Hansen, 1950; Allen, 1954). However, as Allen points out, it is "fallacious to claim that fire should be used in regeneration treatments just because wild fires have helped to maintain Douglas fir in the coast region".

VI. Development of the Climax Types.

1. *The Pattern of Fires.*

Table 1.11 shows the general level of the development of forest types according to soil fertility and the frequency of fires over the last few centuries. Given a low frquency of fires, temperate rainforest would be the climax on all but soils of very low fertility, where is would probably give way to mixed forest. But mixed forest cannot develop on the very poor soils with the present fire frequency and so in Table 1.11 mixed forest is labelled as "future" where there is a combination of very poor soil

and low fire-frequency. Fires prevent the development of the climax type (rainforest) and the stage reached (fire-climax) is determined by the frequency of fire. Fires tend to be more frequent on areas of low soil-fertility because poor soils carry large proportions of highly inflammable species from families such as *Myrtaceae* and *Epacridaceae*.

Because of the frequency with which they can be burnt, the areas of low soil-fertility are the sources of fires which may damage the adjoining forest. It is often difficult to start fires in closed forest and most destruction has come from fires invading from areas of poor-quality forest. In the last century white man has changed this to some extent by making agricultural activities the principal source of forest fires. However, the main pattern of the forest in the Florentine Valley was established before white man arrived in Tasmania; his principal contribution being the 1934 fire and even the course of this fire was largely determined by what had happened before his arrival.

The winds which are associated with severe fire weather are from the north to north-west. Fig 1.2 (*a*) suggests that, owing to topographic protection on the west, fire sources in the Florentine Valley are the important one for the valley itself. There are two main sources. The first is on Tim Shea and the second near Dawson's Road. The sedgeland and eucalypt forest of mixed ages on Tim Shea occupy most of the area of very poor soil derived from conglomerate and quartzite. The plant communities have been repeatedly burnt. The fires have burnt uphill to the south and south-east (with the "fire" winds) and have not spread to the rainforest and old mixed forests on the slopes of the range running from Tim Shea to Mt. Field West. It could be argued that the aboriginal did not visit Tim Shea but white man has done so repeatedly as explorer, prospector, and hunter and his frequent fires have not travelled to the east.

The Dawson's Road area has been the most important source of fires. Small *Poa* plains and adjoining savannahs made the area attractive to the aboriginals. White man, coming from the Derwent Valley, thought the valley to be a good, large-scale agricultural proposition. Most of the young mixed forest shown in Fig. 1.2 (*b*) is 150 years old. This would have resulted from an aboriginal fire as white man did not settle Tasmania until 1801 and certainly up to 1807 (the year of the fire) was not pushing into areas such as the Florentine . The stand which originated after the 1807 fire is only partly intact, as much of it was burnt in the 1934 fire; but it can be traced as fire-killed spars. It is obvious that the 1807 and 1934 fires followed the same path. With topography, fire source and the direction of the fire wind the same, this is to be expected. It is reasonable to assume that the fires which regenerated the old mixed forests also came from the lower Florentine but spread further up the valley. Distance and direction from the fire-sourse is then seen as an important factor in determining the probability of the attainment of climax status. Jackson (1958) has demonstrated this for the Pieman-Waratah region. The presence of rainforest on the steep, west to north-west facing slopes of the Tim Shea-Field West Range is made possible because of low fire-frequency due to the long distance from the fire source.

2. Fire Climax Mixed Forests.

(*a*) *Floristic Changes after Fire.*

Repeated fires (say three or four times per century) produce a forest stand in which there is so much floristic variability in space and time that the term fire-climax cannot be applied to them. Such stands have been described under "Eucalypt Forest" and it is evident that the future cource of their development depends almost entirely on the future history of fires.

In the Florentine Valley, and the areas of Tasmania receiving more than 50 inches of rainfall annually, fire is a complicating factor, structurally and floristically. On all but poor soils, freedom from fire leads to temperate rainforest, the simple nature of which has already been described. Fire will cause simplification only if so frequent that regeneration of the forest species is prevented because the source of seed becomes completly depleted. If some of the species are highly fire-resistant, as for example on the central coast of N.S.W., there may be an elimination of only a proportion of the species by repeated fires (Pidgeon, 1938). Jarrett and Petrie (1929) regarded the forest fire "as a great simplifying factor in the development of these communities" (*regnans* forest) and as "leading to increased purity". In such cases the degree of purification is more apparent than real when a detailed examination is made of the species present.

The destruction of mixed forest (eucalypt plus temperate rainforest) by fire arrests the progress to climax rainforest and starts the forest once again on a course of secondary succession, from relatively many to relatively few species. Thus there is an immediate regeneration of all the species present in the previous stand, some in vastly increased numbers, and the appearance of a few short-lived species.

The most common firewood species is *Erechthites prenathoides* with *Senecio australis* far less common than in areas of lower rainfall. Scattered *Erechthites* become established in the first season and seed profusely. In the second season there is a dense growth of new seedlings with the first year plants growing again in the second year to produce plants 6 feet high. *Urtica incisa, Cirsium vulgare* and *Epilobium* show a similar build up in numbers in the second year and ferns (*Histiopteris Polystichum* and *Hypolepis*) may form dense patches. *Eucalyptus, Nothofagus* and *Atherosperma* appear in large numbers and species which are rare in the virgin forest become common, *e.g., Clematis, Pittosporum, Coprosma;* and *Acacia dealbata,* not present in mature mixed forest, appear in very large numbers.

(*b*) *The Development of the Eucalypts.*

Depending on the speed of the development of the more ephemeral fireweed species and the effect of browsing by marsupials, the eucalypt seedlings may grow vigorously from the time of germination

or take 3-4 years to get above the competing fireweeds and to recover from browsing. Browsing also reduces the number of seedlings. Wild fires in virgin forest usually result in dense stands of eucalypt seedlings and counts of over 200,000 seedlings per acre have been made on millacre quadrats. This is exceptionally high but would be rapidly reduced in five years to numbers not differing from regeneration which originated at the rate of a few tens of thousands per acre. Enough information is available to form a reasonable picture of the reduction in seedling numbers (Fig. 1.15), which is extremely rapid for the first 10 years and very slow from 150 years to 350-400 years when the last eucalypt would be expected to die of old age if the site were not disturbed.

Doubt has been expressed as to the correctness of the statement that fire has perpetuated the eucalypts in the mixed forest. It has been suggested that as the eucalypts become decadent they will fall and eucalypt seedlings become established in the breaks made in the canopy. The one known case has been mentioned. It is clear that there has been a great deal of time for such pockets of seedlings to become established. Until the stand is 200 years old (or younger) reduction in the number of eucalypts per acre is mainly due to competition between the eucalypts for room and new eucalypts could not become successfully established even if understory competition were absent. Thereafter there is room for regeneration to become established, if the eucalypts alone were considered, and this condition applies until the last eucalypts die of old age when the stand is c. 400 years old. For about 200 years there is an opportunity for the eucalypts to regenerate if suitable gaps appear in the canopy of the understory.

(c) *Regeneration in Gaps in the Understorey.*

Large gaps in the canopy of the understory are not common in the Florentine. Such gaps as occur are usually caused by single stems of *Eucalyptus* which fall after their butts have decayed. The dead trees have usually lost most of their crown before they fall. The gaps are generally occupied by *Atherosperma* which is present as seedlings, saplings or small trees before the gaps appear. An example is shown between the 200 and 300 feet marks on the transect in Fig 1.9. Generally, the effective size of gaps is so small that groups of saplings of the understorey species do not occur and such gaps have not been and are not likely to be favourable for the establishment of eucalypts. For eucalypts—

1. The gaps are too small;
2. Undisturbed Aoo and Ao horizons are not good seed-beds;
3. There is not likely to be any seed, as many gaps are caused by the falling of dead trees which have long since shed their last crop of seed and it is very unlikely that eucalypt seed is stored in the surface soil in small gaps for more than a few months.

Holloway (1954) describes forests in the South Island of New Zealand which contain very old matai (*Podocarpus spicatus*). He is of the opinion that the failure of matai to regenerate is due to an adverse climatic change during the life of the ancient matai. This is not the case with eucalypts in mixed forests of the high rainfall areas of Tasmania, as eucalypt regeneration can be obtained naturally or artificially on areas which carry scattered ancient eucalypts provided the canopy of the understory is sufficiently disturbed.

(d) *Longevity of Seed of Acacia dealbata.*

When mixed forest is disturbed *Acacia dealbata* seedlings appear in large numbers. Numerous observations and ring counts have shown that the species does not survive beyond the generation which appears after disturbance of the site and that few trees live for more than 70 years. In forest which has not been disturbed for 350-500 years, *Acacia dealbata* seedlings appear as soon as the stand is opened up and the appearance is so immediate and general over large areas that the only reasonable explanation is that the seed has remained viable in or on the surface soil for 300-400 years. It appears unlikely that birds, &c., could carry sufficient seed in.

It is to be noted that burning is not essential for regeneration of *Acacia dealbata*, as seedlings appear on all roadsides and logging tracks in mixed forest whether the surrounding forest is burnt or not. Only a minor disturbance of the site is needed to allow the seed to germinate, seedlings appearing in the disturbed soil around the butts of single upturned trees in virgin forest. However, such seedlings soon die. Rotten eucalypt logs can be found in some of the temperate rainforest in the Florentine estimated not to have been burnt for 500 years, yet *Acacia* seedlings appear when such stands are disturbed; however, in very low numbers compared with mixed forest. The rate of seed-depletion and the limits of viability are not known.

3. Climax:—Temperate Rainforest.

(a) *Attainment of Climax.*

The climax condition is reached on the death from old age of the generation of eucalypts which arose from the last disturbance of the site. In the past this has meant freedom from fires during the life of the eucalypts. Logging operations now constitute a significant factor of disturbance but, as already noted, differ in important respects from disturbance by wild fire.

In some areas of rainforest no signs of eucalypts could be found despite a search which included digging into long mounds suggestive of the presence of ancient logs. It could not be deduced whether these areas were likely to have carried eucalypts in the last few thousand years.

(b) *Effect of Fire in Rainforest.*

In mixed forest eucalypt seed is not stored on the soil surface for more than a few months, so once the climax condition is reached on more than a few acres the area, if disturbed, will revert to mixed forest only on its margins, i.e., within the range of eucalypt seed-throw. This is uncertain beyond a distance equal to the height of the seed trees (Jacobs, 1955; Gilbert, unpublished thesis). Rainforest species germinate freely immediately after fire and do not need a canopy of *Eucalyptus*

or *Acacia* for protection during their early growth. The seedlings grow slowly and at the end of the second year only a few are more than a few inches high, with large numbers ¼ to ½ inch high. It is inevitable that fireweed species will overtop such slow growing plants. There is no evidence that the fireweeds are needed as a nurse. *Nothofagus* and *Atherosperma* grow faster on open roadsides and on the large bare areas at log marshalling and loading points than in competition with fireweeds. *Nothofagus cunninghamii* is not a " tender " species as it grows on a wide range of sites in Tasmania from near sea level to 4,000 feet, where it is subjected to heavy snow. In the higher rainfall areas of Western Tasmania it will grow on shallow, siliceous soils irrespective of aspect (Jackson, 1958).

Frazer and Vickery (1938) reported that when the *Eucalyptus* seed-trees were removed from around small patches of sub-tropical rainforest in the Barrington Tops district and the small patches later burnt there was immediate regeneration to rainforest. Normally, destruction of tropical and sub-tropical forest is followed by a sere from which the climax forest-species are at first absent. There are no comparable seral stages for temperate rainforest in Tasmania. There may be an early development of an apparently unispecific stage but close observation shows that generally all the rainforest species are present.

(c) *Ecological Status of Atherosperma.*

The ecological status of *Athersperma* is not clear. In most rainforest and mixed stands it is associated with *Nothofagus* and on good sites grows to 90-100 feet compared with 110-120 feet for *Nothofagus*. *Atherosperma* undergoes continuous regeneration by seedlings as well as vegetatively and in terms of recruits to the uper-size classes is usually at a marked advantage compared with *Nothofagus*. It is more tolerant of low light intensities, has a much wider range of seed dispersal (the seeds float like thistle down) and from general observation would appear to tolerate much wetter conditions in the cotyledon and small seedling stage.

Outside the study area there are fairly extensive areas of mixed forest (with *regnans*) in which the understory is essentially pure *Atherosperma*, while there are smaller areas where the species forms pure stands. Occasionally very large *Acacia dealbata* occur in association with *Atherosperma* in these areas, indicating that poor drainage is not the factor which has favoured the formation of the pure stands. Such pure stands are neither particularly sheltered nor excessively exposed and at the same time the macroscpoic features of the soil-profile match those in the adjoining mixed forest.

The course of the development of fairly extensive areas of mixed forest having an understory of pure *Atherosperma* (which, if there were no disturbance of the site, could lead to areas of pure *Atherosperma*) is not known. It was once thought that, given a long period without disturbance, its compartively superior capacity to regenerate would allow *Atherosperma* to capture rainforest sites from *Nothofagus*. However, the frequent association of *regnans* with pure *Atherosperma* shows that disturbances which have been frequent enough to perpetuate *regnans* have not prevented the development of an understory of pure *Atherosperma*.

Atherosperma has a far greater range of seed-dispersal than *Nothofagus*, so should seed of *Nothofagus* not be available in a burnt area, *Atherosperma* is at a marked advantage (as when, for example, all seed is destroyed, there is a poor seed crop, or a second fire occurs before the regeneration from the first has produced seed). A stand of *Nothofagus* probably produces a reasonable quantity of seed each year; the seed begins to be shed early in February, is shed in large quantities until the end of April, in smaller quantities until about the middle of September and then in very small amounts until the following February. Poole (1950) has reported that the seed of New Zealand species of *Nothofagus* is ripe during the winter after flowering and is nearly all shed from the cupule shortly afterwards.

The rate of spread of rainforest has not been studied.

The presence of *Acacia dealbata* in mixed forest is indicative of a disturbance of the canopy of the understory during the previous 50-70 years, and if the forest has not been logged this usually means disturbance by fire. In the areas of pure *Atherosperma* a few very large *Acacia dealbata* are to be found, associated with small patches in which *Atherosperma* died out through failure to regenerate. In spite of the large quantities of seed which have been shed into these gaps each year, seedlings (even at cotylendon stage) can usually be found only on a few *Dicksonia* trunks. There is virtually no litter on the ground and there are no traces of recent fire. In pure stands the ground is partly covered with a mat of *Atherosperma* roots, while the canopy may become so complete that many *Dicksonia* die because of the small amount of light getting through.

Toxic material leached from the leaves or exuded from the roots of *Atherosperma* may be a factor which gives *Atherosperma* an advantage over other understory species. In addition, in pure stands such toxicity could be involved in the apparent instability of *Atherosperma*. In the Derwent and Huon River systems *Atherosperma* generally shows a regenerative advantage over *Nothofagus* and yet understories or stands of pure *Atherosperma* are much less common than stands of mixed *Nothofagus-Atherosperma*. Experimental evidence is required on these points.

VII. Comparisons with Other Forests.

1. *Temperate Rainforest and Mixed Forest with an Understory of Temperate Rainforest Species.*

(a) Tasmania.

Mixed forest is common in Tasmania where the annual rainfall is more than 50 inches. On good soils the eucalypts in the mixture are *regnans*, *obliqua* and *gigantea* but, as rainfall increases, *simmondsii* and *ovata* may occur instead, because rainforest species can spread on to the poorer soils occupied by these two species. At elevation above 2,500 feet, *coccifera*, *urnigera*, *gunnii* and *subcrenulata* may be components of mixed forest. *Gigantea* is present on stabilized talus slopes in western mountains where the rainfall may eceed 80 inches per annum.

As a general statement it can be said that in mied forests in Tasmania the eucalypts in any one stand are even-aged and that their continued existence has depended upon periodic destruction of the stand by fire. Eucalypt regeneration cannot become established unless the understory is more or less completely removed.

Some areas of mixed forest in the Arve Valley (for location see Fig. 1) show much more disturbance of the canopy of the understory of rainforest species than is the case in the Florentine. Gaps caused by falling eucalypts are more numerous and larger, and as a consequence groups of poles of the rainforest species are common. Eucalypt regeneration is absent.

In Tasmania, as mean annual rainfall increases, fire frequency decreases. Towards the West Coast, rainforest is able to spread on to poorer soils, although the trend is halted in many places where large areas of inflammable sedgeland occur on very infertile, acid soils (Jackson, 1958).

In areas receiving less than 50-55 inches of rainfall annually, rainforest tends to be confined to gullies and S.E.-facing slopes. Below 35-40 inches, rainforest is rarely found outside steep-sided gullies facing S.E. and in these cases it is doubtful whether the rainforest would spread to drier slopes even if fires were completely excluded. In the 40-50 inches rainfall belt, fires have been frequent enough to maintain an understory of *Acacia dealbata, A. melanoxylon, A. verniciflua, Pomaderris, Olearia* and *Prostanthera lasianthos,* to name the more common understory species. The extent to which rainforest could spread in this belt, given a greatly reduced fire-freqeuncy, is not clear, since edaphic factors become limiting and the necessary reduction in fire-frequency would occur only if there were a substantial change in climate or man were excluded. As a result of the fire-frequency of the last few centuries, pure rainforest is rare in the 35-40 inches belt and species such as *Eucalyptus regnans* are confined to the moister slopes in stands which do not attain the ages of those in old mixed forests with higher rainfall.

(*b*) Victoria.

Temperate rainforest and mixed-forest are developed only to a limited extent in Victoria. Temperate rainforest is confined to very favourable sites—S.E.-facing gullies and upper slopes, and mixed-forest occurs as a narrow fringe to these restricted areas of rainforest. Patton (1955) describes the Victorian fern gully as true temperate rainforest with *Acacia melanoxylon, A. decurrens, Lomatia fraseri, Atherosperma, Nothofagus* in the upper stratum and *Olearia, Bedfordia, Prostanthera, Zieria* and *Pomaderris* in the second story. Such a forest should be regarded as seral with *Nothofagus* and *Atherosperma,* the only climax species. The limited extent of true temperate rainforest in Victoria compared with Tasmania would appear to be due to hotter and drier summer conditions which make it difficult for rainforest to exist on N.W. slopes. Also the more frequently occurring extreme fire danger would enable fires to burn on S.E. slopes where rainforest and mixed forest might otherwise develop. Bad fires have been frequent since white settlement at Melbourne in 1835. Fergusson and Chinner (1955) list 1902, 1919, 1926, 1932 and 1939 as years in which forest fires caused "great damage, including serious loss of life", although vast areas of virgin *regnans* forest escaped destruction until the last of these fires in 1939.

But devastating forest fires did occur before white settlement and gave rise to extensive even-aged stands of *regnans.* Patton (1930) dismissed pre-white man fires as a factor which had any effect on present associations, partly on the assumption current at the time that *regnans* reached an age of several thousand years and, being a fire-sensitive species, could not have survived if fires had been frequent. However, it is now known that few *regnans* are likely to be more than 400 years old. In the head of the Ada River (Powell Town district of Victoria) pure rainforest is confined to a very small area along the creeks. A narrow band of mixed forest occurs and extending beyond this for several chains are coppice shoots of *Nothofagus* from trees burnt in 1939. This fire went through a small part of the c. 165-year-old stand of *regnans* without killing it. No really old *regnans* are to be seen, even near the creeks, but a few 250?-year-old-trees are scattered through the otherwise even-aged 165-year-old stand, little of which completely escaped the fires of 1939.

There is little doubt that white man's more intensive use of the land has been the cause of an increased fire-frequency in some areas. In the Otways, white man's clearing and burning have caused major changes. Carron and Hall (1954) stated that beech (*Nothofagus cunninghamii*), from which the township of Beech Forest derives its name, was practically extinct in this area.

(*c*) New South Wales and Queensland.
Nothofagus moorei.

Frazer and Vickery (1938) have described the simple structure of *Nothofagus moorei* forest in New South Wales. The inability of *Eucalyptus* to regenerate beneath *Nothofagus* was noted and the presence of old eucalypts among *Nothofagus* was taken as an indication of the advance of the rainforest species. Disturbance by fire would also account for the continued existence of the eucalypts in the mixture but the frequency of fires would need to have been low in order to ensure that *Nothofagus* was not wiped out. If fires are frequent, rainforest species would only make relatively short-term advances into adjoining eucalypt forest and there will be a repeated sequence of advance and destruction. Vegetation illustrated in Frazer and Vickery's 1938 paper appear to be typical of fire edges (Figs. 44, 45, 46, 47, and Plate XII). In one of these (Fig. 47) the butt of a tree shows the partial healing of successive fire-wounds and the ground cover of *Poa caespitosa* also indicates repeated burning. Herbert (1936) pointed out that the success of the advance of *Nothofagus moorei* into eucalypt forest in S.E. Queensland depended upon freedom from fire until *Nothofagus* had formed a closed community.

2. *Mixed Forest with Understory of Sub-Tropical Rainforest Species.*

The mixed forests of Tasmania have a very close counterpart in New South Wales and Queensland, where species such as *Eucalyptus grandis, microcorys, pilularis, saligna* and *Tristania conferta* have been maintained in mixtures with species of the sub-tropical rainforest by past fires. Swain (1928), writing of Queensland, said: "In his time the Queensland aborigine, scorning Mahomet, persuaded the game to come to him by applying his firestick in the springtime to the production of new hunting-grounds baited with grass fresh-shooting from the ashes. The Queensland cattlemen of today, perceiving the Eucalyptus forest forever asserting itself by bark-fall and leaf-fall and twig-fall and shade and canopy against the permanency of his pasturages, takes side with fire against the forests of the coastal hills, to arrest the silvical succession which otherwise and in so far as site factors permit, would develop through Brush Box (*Tristania conferta*) and Rose Walnut (*Endiandra sieberi*) into Araucarian jungle . . . On the slopes *Eucalyptus pilularis* has an advantage over the tenderer jungle trees in its greater hardihood, and this advantage is made binding by the incidence of bush fires. By these means it stays the development of the succession and establishes itself as a fire subsere of some stability, itself regenerating strongly from the ashes of the bush fires which have eliminated its competitors".

Webb (1956) and Baur (1957) also discussed the part played by fire in maintaining mixed forests, where the understories of rainforest species have completely excluded eucalypt regeneration. Nevertheless, several authors look to edaphic factors to explain the composition of mixed-forests (McLuckie and Petrie (1927), Frazer and Vickery (1938) and Burges and Johnston (1953)).

Mixed forests in high rainfall in temperate and sub-tropical Australia apparently has no widespread counterpart in the tropics. Richards (1952) suggests that the *Eucalyptus deglupta* communities in New Britain have depended for their existence on past fires, but in Africa, as in New Guinea and elsewhere, the rainforest passes abruptly into grassland or savannah which is burnt very frequently—Eggeling (1947), Jackson (1956), Morrison *et al* (1948), Richards (1952), Thomas (1945). On the highlands of Tasmania and Eastern Australia fires have played a part in the origin and maintenance of small *Poa caespitosa* plains in rainforest on basaltic soils—Herbert (1938) Baur (1957). Natural re-afforestation of such openings is slowed by frost.

Similarly, on the Pacific Coast of North America, fire has prevented the attainment of climax status for certain mixed *Pseudotsuga-Tsuga* forests (Allen, 1954; Hansen, 1950; Lindsay, 1932). In south-eastern U.S.A., fires have maintained *Pinus* spp. in mixed stands with *Quercus* and *Hicoria* (Barrett, 1943).

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APPENDIX.

Names, with authors, of those plants not contained in Blakely (1934), Curtis (1956). Rodway (1903), or Wakefield (1957).

Araucaria cunninghamii Ait.
Ceratopetalum apetalum D. Don.
Cirsium vulgare (Savi) Ten.
Endiandra sieberi Nees.
Lomatia fraseri R. Br.
Nothofagus moorei Maiden.
Podocarpus spicatus R. Br.
Pseudotsuga taxifolia (Poir) Brit.
Syncarpia subargentea C.T.W.
Tarrieta argyrodedron Benth.
Tristania conferta R. Br.

THE DISTRIBUTION OF TRACE ELEMENTS DURING DIFFERENTIATION OF THE MT. WELLINGTON DOLERITE SILL

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(*Communicated by K. D. Nicholls*)

INTRODUCTION

During a study of the geochemistry of some trace elements in soils developed on dolerite in Tasmania, considerable variation was found in the trace element composition of the parent materials. In order to gain a fuller understanding of the amount and manner of this variation a detailed study was made of the Mt. Wellington sill.

Edwards (1942), in a broad chemical and mineralogical study of dolerites in Tasmania, found variations in composition within the sills and dykes examined. He attributed these changes to fractional crystallization and gravitative differentiation in the cooling magma of the sills, similar to that which is postulated to have occurred in the Skaergaard intrusion of East Greenland and the Palisade sill of New Jersey. The comprehensive study of the distribution of trace elements in the Skaergaard intrusive by Wager and Mitchell (1951) has been a notable contribution to the geochemistry of these elements. Wilson (1950) studied the distribution of some trace elements in the Mt. Wellington sill using a semi-quantitative spectographic method and found some broad trends in composition with depth in the sill which he attributed to differentiation.

As the distribution of trace elements in the dolerite sill was of interest to the general study of differentiation and, in this particular case, a necessary background for a fuller understanding of the variations occurring in the parent material of the soils, it was decided to repeat some of the work previously done and to study additional elements in a greater number of samples.

METHODS

Twenty samples were collected at fairly regular intervals up the Mt. Wellington sill from the Pinnacle Road at sites corresponding to bench marks established by the Geology Department, University of Tasmania.

These samples were broken into small pieces, sub-sampled, and crushed in a steel mortar, which, from experience, has proved to be free of contaminating trace elements. Each sub-sample was finely ground in a mechanical grinder (mullite mortar and pestle) and then mixed with an equal weight of graphite. Co, Zr, Ni, Cu, V, Mo, Ga, and Mn were determined quantitatively using the standard emission spectrographic methods developed by the Spectrographic Group of the Division of Soils. All samples were volatilized in triplicate in a 15 ampere D.C. arc using anode excitation and standards were prepared by the method of successive additions. This method has a precision of $\pm$ 10 per cent. It is believed that for some elements this is also a reliable measure of accuracy and this is supported by results obtained by McKenzie, Oertel and Tiller (1958) for the standard rocks Gl and Wl (Fairbairn, *et al*, 1951).

Zn was determined by X-ray fluorescent spectrography while P and K were determined by chemical methods.

Mineral fractions were separated from some samples by centrifuging the very finely ground rock in bromoform. This procedure was repeated to get a satisfactory separation and the iron ore fraction was removed with a bar magnet. Examination under the petrological microscope showed that there was negligible contamination of the separates analysed.

RESULTS AND DISCUSSION

Table 1 shows the height of each sample above the base of the sill, the height above sea level and the trace element content of the 20 samples collected from the Mt. Wellington sill. Table 2 gives the analyses of the separated mineral fractions.

Distribution of Trace Elements

Cobalt

Cobalt increased gradually with depth for the whole sill, from 35-40 p.p.m. in the upper more differentiated part to 50-55 p.p.m. in the lower basic part. Most of the Co occurred in the pyroxene fraction and was highest in the more iron-rich pyroxenes of the upper part of the sill. Although the iron ore fraction contributed little to the total Co of the rock it had a higher Co content than the pyroxenes and again, the highest values are from the upper part of the sill. Co, presumably, mainly replaced $Fe^{3}+$ iron in these minerals. The plagioclase fraction had a uniformly low Co content throughout the sill at about 15 p.p.m. Although the Co content of the pyroxenes and iron ore was higher in the upper part of the sill, it was more than compensated for by the larger amounts of plagioclase there.

TABLE 1.

Analyses of Samples from the Mt. Wellington Sill

Sample No.	Height above Sea Level	Height above Base Feet	Co ppm	Zr ppm	Ni ppm	Cu ppm	V ppm	Mo ppm	Mn ppm	Ga ppm	Zn ppm	P %	K %
D1	4,166	1,209	37	220	14	140	290	9.0	1,250	25	72	.077	1.26
D2	4,124	1,167	40	200	16	140	350	8.5	1,300	25	89	.070	1.12
D3	4,012	1,055	39	210	18	130	320	9.0	1,250	23	....	....	....
D4	3,925	968	34	190	17	140	320	9.1	1,350	30	....	....	....
D5	3,841	884	36	210	16	130	350	8.4	1,300	26	....	....	....
D6	3,784	827	34	180	18	140	270	8.9	1,250	26	....	....	....
D7	3,666	709	40	170	40	120	340	9.4	1,300	25	....	....	....
D8	3,436	479	44	170	37	150	370	9.1	1,400	25	72	.056	.92
D9	3,377	420	41	130	45	110	370	8.7	1,350	25	....	....	....
D10	3,306	349	53	140	83	100	360	8.3	1,400	20	....	....	....
D11	3,263	306	45	110	98	73	320	7.5	1,300	17	....	....	....
D12	3,240	283	47	110	110	79	340	6.8	1,200	16	64	.035	.56
D13	3,152	195	51	120	120	73	390	9.3	1,300	19	....	....	....
D14	3,130	173	53	130	120	79	430	8.2	1,500	22	....	....	....
D15	3,089	132	53	140	98	86	420	8.1	1,450	22	....	....	....
D16	3,066	109	50	130	90	87	380	8.8	1,250	18	....	....	....
D17	3,000	43	44	130	81	89	360	8.4	1,350	18	....	....	....
D18	2,978	21	51	150	93	97	370	9.8	1,350	20	61	.047	.69
D19	2,957½	½	48	150	88	110	380	9.3	1,650	23	....	....	....
D20	2,957	....	53	150	87	100	380	8.2	1,600	21	57	.047	.64

..... = No data—Analyses based on samples ignited at 500° C.

TABLE 2.

Trace Element Content of Mineral Fractions Separated from Dolerite

Sample No.	Height above Base Feet	Mineral Fraction	Co	Zr	Ni	Cu	V	Mo	Mn	Ga
D2	1,167	Feldspars	17	170	7.4	100	150	6.1	730	26
		Pyroxenes	83	180	36	130	580	11	3,900	11
		Iron Ore	130	570	120	170	2,600	47	4,900	39
D8	479	Feldspars	18	140	17	100	140	6.8	590	24
		Pyroxenes	92	180	86	170	580	12	3,700	12
		Iron Ore	96	470	210	250	2,200	41	5,700	34
D12	283	Pyroxenes	66	96	140	49	460	7.3	2,500	7.4
D18	21	Feldspars	15	93	26	65	160	5.3	450	22
		Pyroxenes	57	99	110	75	410	6.9	2,300	9.1
		Iron Ore	82	330	210	240	960	32	2,000	27

All results expressed as p.p.m.

Nickel

This element has been much more influenced by the processes of differentiation than the other elements studied. The Ni content of the sill was fairly constant at about 15 p.p.m. for the upper 400 feet, increased sharply to about 40 p.p.m. for the 400 feet below this and increased further to a maximum of 120 p.p.m. between 200 feet and 300 feet above the base. This maximum corresponded to the zone of magnesian pyroxenes described by Edwards (1942).

Analysis of the composite mineral fractions showed that, in contrast to Co, Ni readily entered the earlier-formed pyroxenes and iron ore minerals. The data suggested that, in the later stages of crystallization in an iron-enriched magma, the Ni was incorporated a little more readily into the iron ore minerals than the pyroxenes. The Ni content of the plagioclase fraction was low in each fraction studied but increased with depth. Although the Ni distribution in the sill was strongly correlated with the Mg profile shown by Edwards (1942), there must also be significant replacement of Fe^{2+} iron at least in the magnetite.

The Co/Ni ratio is known to change considerably in sequences of rock formed by differentiation processes. This ratio varied sixfold in this sill, from a minimum of 0.43 in the magnesian-rich zone, to a maximum of 2.6 in the uppermost part of the sill. The Co/Ni ratios of the chilled margin, taken to indicate the original magma, and the uppermost part of the sill are similar to the ratios quoted by Rankama and Sahama (1949) for gabbros and granites respectively, although the actual Co and Ni values for the top of this sill are much higher than for granites.

Zirconium

Zirconium decreased gradually with depth from a maximum of 220 p.p.m. in the most acidic differentiates to a minimum of 110 p.p.m. at about 300 feet above the base and then increased to 150 p.p.m. in the "chilled" margin. This agreed with the well-known fact that Zr is highest in the acid igneous rocks. Zr was most abundant in the iron ore fractions and the Zr content of all fractions was highest in the upper parts of the sill because of the increased amount of Zr in the residual magma. Although it is known that Zr^{4+} may replace Fe^{2+} and Ca^{2+} in some minerals, it is possible that the "pyroxene" fraction, as separated, contained some zircons.

Copper

The Mt. Wellington sill had a constant Cu content of about 130 p.p.m. in the upper 600 feet. There was a small peak of concentration 500 feet above the base and this was thought to correspond to the slight accumulation of iron which Edwards (1942) had described. The Cu content was lowest 200-300 feet above the base, corresponding to the zone of maximum magnesium and nickel content.

Cu had entered the later pyroxenes, presumably by replacement of Fe^{2+} iron, with much greater ease than the earlier magnesian pyroxenes. The higher Cu content of the later-formed feldspars could be due to the greater ease of replacement of Na in the more sodic plagioclase, combined with a higher concentration of Cu in the residual magma. The Cu contents of the plagioclase and pyroxene fractions were of the same magnitude in each rock sample; copper was, however, more abundant in the iron ore fraction. Although this is further evidence that Cu is readily replacing Fe^{2+} iron,

there is the possibility, as has been discussed by Wager and Mitchell (1951) and Cornwall and Rose (1957) that some may have occurred as the sulphide or metal.

Manganese

Although the Mn content of the rock samples did not vary significantly with depth, there was a small increase from the top to 500 feet above the base. Below this the values were usually lower except for a peak at about 150 feet above the base. Analyses of the mineral fractions showed that Mn was most abundant in the iron ore minerals, and to a slightly less extent in the pyroxenes with the highest values in the upper parts of the sill. The Mn content of the plagioclase fraction was much lower but still increased in the upper parts of the sill.

Molybdenum

This element was fairly constant at about 9 p.p.m. throughout the whole sill except for significantly lower values about 300 feet above the base, corresponding again to the zone of early formed magnesian pyroxenes. Whereas molybdenum was fairly constant at about 6 p.p.m. in all the plagioclase fractions, its abundance in the later formed pyroxenes was much greater than in the earlier ones. Mo was highly conctenrated in the iron ore fractions, particularly in the upper parts of the sill.

Vanadium

Although the changes were small there was a definite tendency to increase towards the bottom of the sill. The vanadium contents of the plagioclase and pyroxene fractions were each fairly constant throughout the sill with much higher values for the latter fraction. Vanadium was most abundant in the iron ore fraction in which V^{4+} could readily replace Fe^{3+} and Ti^{4+}.

Gallium

The uniformly high content of about 25 p.p.m. in the upper 800 feet of the sill corresponds closely with the higher plagioclase content found by Joplin and Jaeger (1957). The lowest values found, 16 p.p.m. 300 feet above the base, occur in the zone of magnesium enrichment. Apparently Ga replaces the larger Fe^{3+} ion of magnetite more readily than the smaller Al^{3+} ion of the feldspars for the mineral separations showed that Ga was most concentrated in the iron ore minerals and, to a less extent, in the plagioclase. Because of the large amounts of plagioclase present in the rock, compared to the minor amounts of iron ore, this has determined the Ga distribution. Although the Ga content of the plagioclase fraction was fairly constant in each case, that of the pyroxenes and iron ore minerals increased in the upper part of the sill suggesting that Ga entered these minerals more readily in the later stages of crystallization.

Zinc

The six rock samples analysed for this element showed a gradual decrease in content with depth and suggested that the residual magma had been enriched with respect to Zn.

Phosphorus and Potassium

Although these elements were not studied to the same extent as the trace elements, it was considered that the few results obtained warranted inclusion in this discussion. Values for potassium agree very well with the corresponding values of Edwards (1942). Results for both P and K support the evidence of others that these elements are concentrated in the residual magma and are, therefore, most abundant in the later differentiates.

General Discussion

Although significant changes with depth have been shown for some trace elements in this sill, they do not compare, with the possible exception of Ni, with the great variations found between the various differentiates of the very much larger Skaergaard intrusive. However, the changes which have been noted generally agree with the conclusions drawn from other studies on the effect of differentiation of basic magma on the geochemistry of the trace elements.

These changes within the Mt. Wellington sill can be summarized as follows: Of the elements studied only Ni is strongly concentrated in the early differentiates. Co, Mn, Mo, Zn, V and Ga did not show such marked variations throughout the sill but, of these, Co and V were more abundant in the early differentiates, Ga and Zn were higher in the later differentiates and Mo was impoverished in the zone of magnesian pyroxene accumulation. Cu and Zr were more strongly concenterated in the residual magma and therefore were most abundant in the upper part of the sill. Wilson (1950) found similar trends for Ni and Cu and also showed that Cr was strongly concentrated near the base of the sill.

Some Comments on Differentiation of the Mt. Wellington Sill

The results show no significant difference in composition between the samples collected at the contact (D20) and six inches above it (D19) and the average composition of these samples has been considered as the composition of the original magma. This makes the usual assumptions that the magma being intruded was homogeneous throughout, that no alteration of the margin or incorporation of country rock had occurred and that solidification occurred too quickly in this narrow margin to be affected by the differentiation processes which occurred in the cooling magma above. Sample D18, collected 20 feet above the contact, does not differ significantly from the analysis of the "chilled" margin, except for Mn, and supports the idea that there had been no significant differentiation, at least with respect to these trace elements, in the lower 20 feet of the sill. Results have shown that above this level the processes of differentiation have had a real significance on the trace element composition of the sill.

The average composition of the sill was calculated assuming that the analysis of each sample represented the dolerite of its part of the sill (weighting each analysis according to the amount represented) and that the small variations in rock

TABLE 3.—*The Average Composition of the Mt. Wellington Sill*

Composition of Sill	Co	Zr	Ni	Cu	V	Mo	Mn	Ga
Calculated Weighted Average....	39	150	47	105	320	8.4	1,400	21
*Assumed Composition of Magma	51	150	88	105	380	8.8	1,600	22

* Average of the analyses of samples D19 and D20. Results expressed as p.p.m.

TABLE 4.—*Analyses of Jurassic Dolerite from Different Localities in Tasmania*

Sample No.	Locality.	Co ppm	Zr ppm	Ni ppm	Cu ppm	Mo ppm	Mn ppm	Zn ppm	P %	K %
H166/16	10 m. W. of Geeveston	42	110	86	75	7.9	1,300	42	.041	.65
H165/12	2 m. S. of Henrietta	58	91	140	60	8.4	1,650	51	.034	.44
H164/11	1½ m. S.W. of Devonport	44	99	110	62	8.1	1,300	57	.035	.55
H159/12	7 m. S.E. of Tarraleah	44	150	52	110	8.8	1,400	72	.051	.82
H167/12	3 m. S.W. of Kempton	48	140	69	89	9.3	1,400	70	.044	.73
H131a/8	1 m. S. of Western Lagoon	46	140	65	110	7.9	1,350	70	.050	.82
H129a/6	2 m. W. of Ross	46	170	63	99	8.5	1,150	63	.051	.98
H160/12	1½ m. E. of Hamilton	48	160	58	110	8.3	1,350	76	.050	.84
H127a/10 ..	2½ m. S.W. of Nugent	34	180	23	140	7.6	1,100	73	.062	1.07
H86a/11	4 m. E. of Forcett	48	150	79	100	8.6	1,350	72	.047	.71
H163/11	1 m. S. of Hadspen	37	140	58	80	7.9	1,250	80	.046	.76
H128a/11 ..	3 m. N.E. of Gretna	37	130	66	81	8.1	1,150	57	.028	.84
H161a/10 ..	Near top of Mt. Nelson	46	200	26	140	8.0	1,300	84	.061	1.09
H162/10	Near bottom of Mt. Nelson	58	87	140	58	7.6	1,350	57	.029	.35
H126a/9	3 m. N. of Sorell	28	195	8	110	8.3	1,250	....	. .	
H174/10	5 m. N.W. of Richmond	32	138	44	97	7.6	1,380	...	...	
H173/12	1 m. S.W. of Brighton	30	94	67	65	7.9	1,190	..		

..... = No data—Analyses based on samples ignited at 500° C.

density (Joplin and Jaeger, 1957) would not be sufficient to affect any conclusions made. This calculated average composition of the sill is compared with the assumed composition of the magma in Table 3.

It may be seen that the average composition of the sill is lower than the magma for Mn, V, Co, and, in particular, Ni. It happens that Ni is also the element most influenced by the processes of differentiation. Providing that the assumptions concerning the composition of magma are correct, it follows that a large proportion of the Ni of the introduced magma has been lost from the column during differentiation. Although there is evidence (Edwards, 1942) that approximately 200 feet of the sill has been eroded away this could not account

for the noted discrepancy. Ni has been shown by Wager and Mitchell (1951), Storm and Holland (1957) and others, to have its lowest content in the uppermost part of differentiated intrusives, whereas the average Ni and Co contents of this eroded portion of the sill would have to be approximately 300 p.p.m. and 100 p.p.m. respectively to account for the discrepancy noted.

The analytical data of Edwards (1942) suggest that the average Mg content of the sill is also much lower than would be expected if the "chilled" margin truly represents the composition of the magma. Furthermore, it is noted that the Mg contents of all "chilled" margins analysed, including both lower and *upper* contacts, show very little variation. This supports the basic assumption concerning the composition of the magma, as the upper contact is not likely to have received any elements such as Mg and Ni during differentiation even if it did remain fluid enough for a sufficient period. Wilson (1950) noted that the Ni and Cr composition of the base was higher than the average for the sill but he claimed he had evidence for differentiation in the "chilled" base and suggested that this base was not indicative of the magma but that it had received additions during differentiation.

There is, therefore, reasonable doubt whether the dolerite "column", as sampled,, represents a simple case of vertical differentiation in a closed chamber. There has possibly been some lateral movement of early-formed magnesian pyroxenes, the main host of the Ni, to an adjacent part of the sill or through a possible vent in the floor of the sill which sealed on partial cooling of the magma. Actually, the dolerite "column", as sampled from the Pinnacle Road, represented only a very oblique section of the sill, and sampling would be necessary in horizontal as well as vertical planes to check any lateral movement of materials. Detailed studies on vertical bore cores available for some dolerite sills in other parts of Tasmania would be very worth-while.

Dolerite in Other Parts of Tasmania

Many samples of dolerite were analysed from several parts of Tasmania in connection with the basic study of the soils formed on dolerite. These results, together with the general locality of each sample, are shown in Table 4. The range in composition found and the relation between the content of the different trace elements show that differentiation processes, similar in effect to those described in this paper, are very widespread in Tasmania. For example, it may be seen that, in general, samples with the high Ni contents have low Cu and Zr contents and vice versa. By noting this type of relationship a good approximation can often be made to the relative position of the sample in its original intrusive body.

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AN ESTIMATE OF TRAVEL EXPENDITURE BY NON-TASMANIANS IN TASMANIA AND BY TASMANIANS OUTSIDE TASMANIA, 1952-53 TO 1956-57

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A. EXPENDITURE BY NON-TASMANIANS IN TASMANIA

Expenditure on travel by non-Tasmanians in Tasmania can be broken up into two parts: expenditure by visitors who stay for more than one day and expenditure by day-visitors, the latter consisting almost conclusively of passengers on those overseas liners which call at Hobart for one day on their way from Sydney to the United Kingdom via Melbourne. Separate estimates have been made for each of these two parts of the total for the years in question and a detailed description of the methods used follows.

1. Expenditure by Visitors Who Stayed for more than One Day.

This was estimated in two stages. To begin with, the *number* of visitors who stayed for more than one day was estimated for each of the years concerned. Then, for each year, an estimate was made of the *per capita expenditure* in Tasmania of this type of visitor; and finally, this per capita figure was multiplied by the number figure estimated at the first stage to arrive at the total expenditure figure. Each of these two stages will now be described in turn.

(*a*) *The Number of Visitors Who Stayed for more than One Day*

Visitors to Tasmania who stayed for more than one day constitute one element of the "arrivals" figure collected by the Deputy-Commnowealth Statistician. The other two elements are (1) Tasmanians returning home after a visit outside the State, and (2) people migrating to Tasmania from overseas or from other Australian States, including Tasmanians who are returning home after a period of residence elsewhere. Thus, the number of visitors to Tasmania who stayed for more than one day can be obtained by subtracting from the Statistician's arrivals figure the sum of (1) and (2) above. This was the method used. We shall now set out the arrivals figure for each of the years of interest and explain how (1) and (2) were estimated for these years.

The arrivals series, as supplied by the Statistician, is set out in Table 1.

TABLE 1.—*Number of Arrivals in Tasmania*

Year.	No.
1952-53	125,514
1953-54	127,679
1954-55	133,298
1955-56	138,407
1956-57	148,295

To estimate the number of Tasmanians returning after a visit outside the State it was assumed, first of all, that the number of Tasmanian visitors returning in each year was the same as the number departing in that year,(1) and an estimate was then made of the number departing.

For this purpose use was made of a survey conducted by the Tasmanian Government Tourist Office during the 1953-54 tourist season. The survey procedure adopted by the Tourist Office was to provide every person leaving Tasmania during the month of November, 1953, and during the period 18th January to 20th February, 1954, with a questionnaire which he was requested to complete. Questions were asked about a number of matters, including place of residence, reason for visiting Tasmania, amount spent on the visit under various heads and so on. The questionnaire was addressed primarily to non-Tasmanians who were returning home after a visit to the State, but there were a few questions which were applicable to Tasmanians also and Tasmanians rceiving the questionnaire were asked to complete it as far as possible.

(1) This amounts to assuming, for each year, that the number who returned in the year, having departed in some previous year, was equal to the number who departed in the year but returned in some later year. This can be seen fairly easily with the help of five symbols, namely:—

(*a*) The number departing and returning in a particular year.
(*b*) The number departing in a particular year and returning in some subsequent year.
(*c*) The number returning in a particular year who departed in some previous year.
(*d*) The total number returning in a particular year.
(*e*) The total number departing in a particular year.

In terms of these symbols our assumption is that, for each year, $(d) = (e)$. But $(d) = (a) + (c)$ and $(e) = (a) + (b)$.

Thus, our assumption is that, for each year, $(a) + (c) = (a) + (b)$, which amounts to assuming that, for each year, $(c) = (b)$.

The questionnaire was completed by 1308 persons in the first period (of whom 274 were Tasmanian residents) and by 1980 persons in the second period (of whom 160 were Tasmanian residents). These two sets of persons can be regarded as two samples, of size 1308 and 1980 respectively, from the population consisting of all persons departing from Tasmania during the 1953-54 tourist season.

In the case of the first sample, the proportion of "Tasmanian Departures" to "Total Departures" was $\frac{274}{1308}$ and, in the case of the second, $\frac{160}{1980}$. For the two samples combined, the proportion was $\frac{274 + 160}{1308 + 1980}$ or 0.132(2).

We are now in a position to explain the way in which the survey just discussed was used to estimate the number of Tasmanians visiting places outside the State during each of the years 1952-53 to 1956-57. The method used to make this estimate was simply to obtain from the Statistician the figure for total departures from the State in each of these years and multiply this figure by 0.132, this being the proportion of Tasmanian departures to total departures as estimated from the two samples of departures taken by the Tourist Office during the 1953-54 season.

As explained earlier, it was assumed that the number of Tasmanian visitors *returning* in each of the years 1952-53 to 1956-57 was the same as the number departing. Thus, from the calculations described in the preceding paragraph, an estimate was obtained for the number of Tasmanians *returning* to Tasmania after a visit outstide the State in each of the years of interest. This estimate is set out in Table 2.

TABLE 2.—*Number of Tasmanians Returning after Visit Outside State*

Year.	No.
1952-53	16,088
1953-54	16,753
1954-55	17,514
1955-56	18,388
1956-57	19,208

As explained earlier, the method used to estimate the number of visitors to Tasmania who stayed for more than one day was to deduct from the Statistician's arrivals figure (1) the Tasmanians returning home after a visit outside the State, and (2) the people migrating to Tasmania from overseas or from other Australian States, including Tasmanians returning home after a period of residence elsewhere. Having set out the arrivals series and explained how the series (1) was estimated, it now remains to explain the estimation of the series for (2).

Pople migrating to Tasmania consist of (*a*) non-Australian-born and (*b*) Australian-born. The number in each of these two groups was estimated separately.

(2) This figure is, in effect, a weighted arithmetic average of the two sample figures.

The number in (*a*) was estimated by Mr. T. O. Mellor, of the Commonwealth Immigration Department, from information in his department's files. Mr. Mellor's estimates are set out in Table 3.

TABLE 3.—*Number of Non-Australian-Born Migrating to Tasmania*

Year.	No.
1952-53	2.498
1953-54	1,399
1954-55	1,957
1955-56	1,308
1956-57	1,797

Th estimate of the number of Australian-born who migrated to Tasmania was based on information contained in a paper entitled "Some Interesting Trends in Tasmania's Population", which was read to the Tasmanian Branch of the Economic Society of Australia and New Zealand in 1956 by Mr. J. C. Stephen, Deputy Commonwealth Statistician for Tasmania. From this paper (Table 4) it was learned that the number of Australian-born, other than Tasmanians, who were enumerated in Tasmania in the 1947 Census was 18,978. The corresponding figure for the 1954 Census supplied by Mr. Stephen was 24,575. Thus, at the 1954 Census date, the number of non-Tasmanian Australian-born who were in Tasmania was greater than at the 1947 Census date by 5,597.

To estimate the number of Australian-born who migrated to Tasmania in each of the years 1952-53 to 1956-57 we assumed, to begin with, that the above figure of 5,597 represented the total number of Australian-born who migrated to Tasmania between 30th June, 1947, and 30th June, 1954. We next assumed that this total was spread evenly over the seven years between the two Census dates and so arrived at the figure of 800 for the number of Australian-born who migrated to Tasmania in each of the years 1947-48 to 1953-54. Finally, we asumed that this figure held for each of the last three years of our period as well as for the first two.

The procedure just outlined suffers from a number of fairly obvious weaknesses. In the first place the total number of Australian-born who migrated to Tasmania in the years 1947-48 to 1953-54 may differ from the figure 5,597 (the difference between the number of non-Tasmanian Australian-born in Tasmania at 30th June, 1954 and 30th June, 1947) for the following two reasons:—

(*a*) The figure 5,597 is the difference between the number of non-Tasmanian Australian-born who were *enumerated* in Tasmania at 30th June, 1954 (24,575) and at 30th June, 1947 (18,978). Both the figures, 24,575 and 18,978 therefore, contain a certain number of non-Tasmanian Australian-born who were not living in Tasmania at the Census date i.e., had not migrated to Tasmania, but who were merely paying a visit. The figure 5,597 differs, on this account, from the figure we take it to be unless the number of visitors happened to be the same on both Census dates.

(*b*) The figure 5,597 almost certainly understates the number of Australian-born who migrated to

Tasmania in the seven years beginning 1947-48, since the manner of its calculation is such that no account is taken either of (*a*) those non-Tasmanian Australian-born who migrated to Tasmania during the period and left it again before the end of the period, or of (*b*) those Tasmanians who returned home during the period after a period of residence elsewhere.

The discrepancy, if any, attributable to (1) could be offset by that attributable to (2), since (1) could as well lead to an overstatement as to an understatement, but there is no real reason to expect that this off-setting has occurred.

The second fairly obvious weakness of the procedure used to estimate the number of Australian-born who migrated to Tasmania in the years 1952-53 to 1956-57 lies in the assumptions that the total number of Australian-born migrants for the seven years beginning 1947-48 was spread evently over those years and that the figure which applied for the years 1952-53 applied also for the years 1953-54 to 1956-57. These assumptions are baseless. On the other hand, there is no reason to think that they are very wide of the mark, and, even if they are (percentage-wise), they cannot be far out absolutely so long as the figure which has been used for the 1947-48 to 1953-54 total (the figure 5,597) is anywhere near right.

As already indicated, the number of Australian-born who migrated to Tasmania in each of the years 1952-53 to 1956-57, as estimated by the procedure just discussed, was 800. Using this information, together with that shown in Table 3, we can construct Table 4, which shows the total number migrating to Tasmania in each of the years of interest.

TABLE 4.—*Total Number Migrating to Tasmania*

Year.	No.
1952-53	3,298
1953-54	2,199
1954-55	2,757
1955-56	2,108
1956-57	2,597

We can now subtract the figures shown in Tables 2 and 4 from those shown in Table 1 to get a figure for the number of visitors to Tasmania who stayed for more than one day, which figure is our immediate objective. The result of the subtraction is set out in Table 5 below.

TABLE 5.—*Number of Visitors to Tasmania Who Stayed More than One Day*

Year.	No.
1952-53	106,128
1953-54	108,727
1954-55	113,027
1955-56	117,911
1956-57	126,490

(*b*) *Per Capita Expenditure of Visitors who Stayed for More than One Day*

The per capita expenditure of visitors who stayed for more than one day was estimated in two stages. The first was to estimate the figure for the year 1953-54 and the second was to use this figure and certain additional information to estimate the figure for each of the other years of interest. Let us take these two stages in turn.

The starting point for the first stage was the second of the two sample surveys conducted by the Tasmanian Government Tourist Office during the 1953-54 tourist season, to which we have already referred[3]. This survey produced information about the total expenditure on their holiday undertaken by 1715 visitors to the State in that year—the 1820 visitors who returned the questionnaire, less 69 who returned it incomplete as regards expenditure.

Some of this expenditure was, of course, undertaken before the visitors in question left. All of them, presumably, paid for their passage to Tasmania before leaving, some of them for their return passage and some for their accommodation and transport in Tasmania (for example, those coming to the State on a Pioneer Tour); and the first step in stage one was to deduct the amount of their expenditure which was thus prepaid from the total expenditure figure produced by the survey.

The best that could be done in this direction was to deduct one-half of the total expenditure on fares undertaken by the visitors concerned, the figure for which was also produced by the survey[4]. This gave a figure of £72,471 for the total expenditure undertaken in Tasmania by the 1751 visitors or £41.39 per head.

The latter figure represents the per capita expenditure in Tasmania *of a sample of the visitors* who came to the State for more than a day during the year 1953-54. The final step of the first stage, the determination of the figure for 1953-54, was to asume that the per capita figure for all visitors who came to the State for more than one day in that year was the same as for the sample of 1751, an assumption which should not cause much trouble in view of the fact that the sample is quite a large one.

So much for the first stage of our estimate of the per capita expenditure of visitors to Tasmania who stayed for more than one day. The starting point for the second stage was the figure for 1953-54, together with information provided by the Government Tourist Office which indicated that the cost of the most popular "round tour" of the State had increased at the rate of about 3% per annum over the period 1952-53 to 1956-57.

On the basis of this information, it was assumed that the per capita expenditure of those visitors to the State who stayed for more than one day increased by 3% per annum over the period in which we are interested, and this assumption, together with the figure for 1953-54, was sufficient to give us the per capita figure for each of the other years.

The complete series, estimated in the manner just described, is set out in Table 6.

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[3] See above, page 159.

[4] This amounts to assuming that the only prepayments were in respect of the outward passage. As we have already indicated, there were, in all probability, prepayments in respect of the return passage and in respect of accommodation in Tasmania as well.

TABLE 6.—*Per Capita Expenditure in Tasmania by Visitors Who Stayed for More than One Day.*

Year.	£
1952-53	40.18
1953-54	41.39
1954-55	42.63
1955-56	43.91
1956-57	45.23

(c) Total Expenditure by Visitors Who Stayed for More than One Day

By multiplying the figures in Table 5 by those in Table 6 we arrive at the total expenditure in Tasmania by visitors who stayed for more than one day. This is shown in Table 7.

TABLE 7.—*Total Expenditure in Tasmania by Visitors Who Stayed for More than One Day*

Year.	£
1952-53	4,264,223
1953-54	4,500,211
1954-55	4,818,341
1955-56	5,177,472
1956-57	5,721,143

2. Expenditure by Day-Visitors

Total expenditure by day visitors was taken to be identical with the total cost of the all-inclusive tours arranged by the Government Tourist Office for non-disembarking passengers on overseas liners calling for one day at Hobart en route to the United Kingdom. This information, supplied by the Tourist Office, is shown for each of the years 1952-53 to 1956-57 in Table 8.

TABLE 8.—*Total Cost of Tours Arranged for Passengers on Overseas Liners calling at Hobart.*

Year.	£
1952-53	1,025
1953-54	1,220
1954-55	2,291
1955-56	2,292
1956-57	4,014

In fact, the above figures slightly understate the total expenditure by day visitors for two reasons. In the first place, they do not include the expenditure on sundries, e.g., sweets, incurred in the course of the tours by the people for whom they were arranged. Seconly, they do not include the expenditure resulting from the visits of passenger ships to Tasmanian ports other than Hobart, of which there were a few during the years 1952-53 to 1956-57.

3. Total Expenditure in Tasmania by Non-Tasmanian Visitors

Total expenditure in Tasmania by non-Tasmanian visitors can now be found by adding the figures in Tables 7 and 8. The result is set out in Table 9.

TABLE 9.—*Total Expenditure in Tasmania by Non-Tasmanian Visitors*

Year.	£
1952-53	4,265,248
1953-54	4,501,431
1954-55	4,820,632
1955-56	5,179,764
1956-57	5,725,157

B. EXPENDITURE BY TASMANIANS OUTSIDE TASMANIA

Expenditure by Tasmanian visitors outside Tasmania consists of (*a*) expenditure in the rest of Australia, and (*b*) expenditure outside Australia. Each of these was estimated separately.

1. Expenditure by Tasmanian Visitors in the Rest of Australia

Expenditure by Tasmanian visitors in the other Australian States in each of the years 1952-53 to 1956-57 was estimated, first of all, by estimating the number of Tasmanians who visited each of the other States in each of these years and then by estimating the per capita expenditure which they undertook there, multiplying the two and adding. Each of these two stages in the final estimate will now be described in turn.

(a) The Number of Tasmanians Who Visited Each of the Other Australian States

The first step here was to find the number of Tasmanians who visited all of the other States combined in each of the years 1952-53 to 1956-57. To do this we took the estimate of the number of Tasmanians who left Tasmania on a visit in each of these years, presented in Table 2 above, and deducted the number of Tasmanians who visited other countries in each year.

The latter was taken to be identical with the number of new passports issued to, and old passports renewed by Tasmanians in each year, information as to which, supplied by Mr. T. O. Mellor, is presented in Table 10.

TABLE 10.—*Number of New Passports Issued To, and Old Passports Renewed by Tasmanians*

Year.	No.
1952-53	485
1953-54	505
1954-55	641
1955-56	688
1956-57	725

Actually, the figures set out in Table 10 may not be identical with those for the number of Tasmanian visitors to other countries since there will, presumably, be some visitors to overseas countries who do not require either the issue of a new passport or the renewal of an old one—those who hold a current passport, mainly business-men who travel abroad frequently—and some applicants for the issue or renewal of a passport who do not intend to travel abroad—those, mainly New Australians, who feel safer, somehow, if they hold a current passport. These two types of error work in opposite directions, however, and there is a good chance that they will offset each other more or less exactly.

The number of Tasmanians who visited all of the other Australian States combined was found, then, by deducting the figures in Table 10 from those in Table 2. The result is shown in Table 11.

TABLE 11.—*Number of Tasmanians Who Visited All Other Australian States*

Year.	No.
1952-53	15,603
1953-54	16,248
1954-55	16,873
1955-56	17,700
1956-57	18,483

The next step was to determine, for each year, the proportion of the Tasmanian visitors to the mainland States who went to each of them. Here again use was made of the second of the two sample surveys undertaken by the Tasmanian Government Tourist Office during the 1953-54 season. This survey covered 1756 visitors from the mainland States (the 1820 visitors who completed the questionnaire less 64 from overseas countries), and provided information about the home State of each of them. From this information it was possible to construct Table 12, which shows the proportion of the 1756 mainland visitors returning the questionnaire who came from each State.

TABLE 12.—*Proportion of 1756 Mainland Visitors Returning Questionnaires Who came from State*

State.	%
Victoria	0.5615
New South Wales	0.2887
South Australia	0.08485
Queensland	0.03588
Western Australia	0.02221
Aust. Capital Territory	0.00683

In order to find, for each year, the proportion of Tasmanian visitors to the mainland States who went to each of them it was assumed (1) that, in 1953-54, the proportion of all mainland visitors to Tasmania who came from Victoria was 0.5615 (the figure which applied in the sample of 1756), the proportion who came from New South Wales was the sample figure of 0.2887 and so on for each of the other States; (2) that in 1953-54- the proportion of Tasmanian visitors to the mainland who went to Victoria was the same as the proportion of mainland visitors to Tasmania who came from Victoria (that is 0.5615 by virtue of assumption (1)) and similarly for each of the other States; and (3) that the proportion of Tasmanian visitors to the mainland who went to each of the six mainland States was the same in each of the other years of interest as in 1953-54.

The combined effect of these three assumptions, none of which is likely to be far out, is that the figures in Table 12 give, for each year, the proportion of Tasmanian visitors to the six mainland States who went to each of them.

The final step in estimating the number of Tasmanians who visited each of the other Australian States in each of the years 1952-53 to 1956-57 was to apply the proportions in Table 12 to the figures in Table 11. The result is shown in Table 13.

(b) *Per Capita Expenditure by Tasmanian Visitors in each of the Other Australian States*

To estimate the per capita expenditure of Tasmanian visitors to each of the mainland States in those States, use was made again of the second of the Tourist Office's 1953-54 sample surveys.

It will be recalled that, in the course of this survey, 1,751 visitors to Tasmania provided information about the total expenditure which they had incurred in relation to their holiday in Tasmania[5]. Of these, 962 were from Victoria, 487 were from New South Wales, 146 from South Australia, 57 from Queensland, 34 from Western Australia, 10 from A.C.T., and the remaining 55 from overseas countries.

As a first step, the per capita expenditure in Tasmania of the 962 Victorian visitors was arrived at by dividing the total amount which they spent on their holiday, less one-half of their fares[6], by 962—the resulting figure being £32 4s., and similarly for the other six States.

It was next assumed (1) that the per capita expenditure in Tasmania of all Victorian visitors in 1953-54 was £32 4s., the figure for the sample of 962, and so on for each of the other States; (2) that the per capita expenditure of Victorian visitors grew at the rate of 3% per annum during the period 1952-53 to 1956-57 and similarly for visitors from each of the other mainland States [7]; and (3) that the per capita expenditure in Victoria of Tasmanian visitors to that State was identical, in each of the years 1952-53 to 1956-57, with the per capita expenditure in Tasmania of Victorian visitors to Tasmania, as given by assumptions (1) and (2), and so on for each of the other States.

The figures for the per capita expenditure in each of the other Australian States by Tasmanian visitors arrived at in this way, are shown in Table 14.

(5) See above, page 159.
(6) See above, page 159.
(7) See above, page 159.

TABLE 13.

Year	Number of Tasmanians who Visited—						
	Vic.	N.S.W.	S.A.	Q'land	W.A.	A.C.T.	Total
1952-53	8,760	4,505	1,320	560	347	107	15,603
1953-54	9,123	4,691	1,379	583	361	111	16,248
1954-55	9,475	4,871	1,432	605	375	115	16,873
1955-56	9,938	5,111	1,502	635	393	121	17,700
1956-57	10,378	5,337	1,568	663	411	126	18,483

TABLE 14.

Year	Per Capita Expenditure of Tasmanian Visitors to—					
	£ Vic.	£ N.S.W.	£ S.A.	£ Q'land	£ W.A.	£ A.C.T.
1952-53	31.46	49.64	45.03	53.71	59.14	38.06
1953-54	32.40	51.13	46.38	55.32	60.91	39.20
1954-55	33.37	52.66	47.77	56.98	62.74	40.38
1955-56	34.37	54.24	49.20	58.69	64.62	41.59
1956-57	35.40	55.87	50.68	60.45	66.56	42.84

(c) *Expenditure in the Rest of Australia by Tasmanian Visitors*

The Total expenditure in the rest of Australia by Tasmanian visitors was now arrived at by multiplying each figure in Table 13 by the corresponding figure in Table 14 and summing over States for each year. The results are shown in Table 15.

TABLE 15.—*Expenditure in Other States by Tasmanian Visitors*

Year.	£
1952-53	613,330
1953-54	658,830
1954-55	703,739
1955-56	760,384
1956-57	809,158

2. Expenditure in Overseas Countries by Tasmanian Visitors

Expenditure outside Australia by Tasmanian visitors was estimated in two steps. The first was to estimate the number of Tasmanians who visited other countries in each of the years 1952-53 to 1956-57 and the second was to estimate their per capita expenditure in those countries. The manner in which the number of Tasmanians who visited other countries was estimated has been explained already and the estimate itself presented in Table 10. Thus, it only remains to explain how we arrive at our estimates of the per capita expenditure in overseas countries of Tasmanian visitors to those countries.

This estimate was made with the assistance of Mr. I. H. Smith, of the Travel Department of the Bank of New South Wales. From the applications for foreign currency for purposes of travel, made by customers of the bank under exchange control regulations, Mr. Smith was able to estimate that the per capita expenditure in overseas countries undertaken by customers of the bank for the purpose of travel there, was approximately £A360 in each of the years 1952-53 to 1956-57.

Since something like 100 customers of the bank travelled abroad in each of these years, this per capita figure of approximately £A630 relates to a sample of Tasmanian visitors to overseas countries which is quite large, both absolutely and in proportion to the number of the population. There is considerable justification, therefore, for assuming that the per capita figure for the population was the same as that for the sample constituted by the customers of the Bank of New South Wales; and this assumption was, in fact, made. In this way we arrived at a figure of £A630 for the per capita expenditure undertaken in overseas countries by Tasmanian travellers in each of the years 1952-53 to 1956-57.

By applying this figure to each of the passport figures presented in Table 10 we arrived at the total expenditure undertaken in overseas countries by Tasmanian visitors to those countries in each of the years 1952-53 to 1956-57. This set of figures is set out in Table 16.

TABLE 16.—*Expenditure in Overseas Countries by Tasmanian Visitors*

Year.	£
1952-53	305,550
1953-54	318,150
1954-55	403,830
1955-56	433,440
1956-57	456,750

3. Total Expenditure Undertaken Outside Tasmania by Tasmanian Visitors

By summing the figures presented in Tables 15 and 16, the figures for the total travel expenditure undertaken outside Tasmania by Tasmanian visitors which are shown in Table 17, were arrived at.

Year.	£
1952-53	918,880
1953-54	976,980
1954-55	1,107,569
1955-56	1,193,824
1956-57	1,265,908

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THE INTERTIDAL ECOLOGY OF THE MONTEMAR AREA, CHILE

by

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(With 20 Text Figures, 3 Plates and 4 Tables)

ABSTRACT

A description is given of the zonation at Montemar, near Valparaiso, on the Chilean coast. The zonal pattern is a barnacle-algal type with the Infralittoral fringe dominated by large brown algae. The Supralittoral fringe is poorly developed, littorines forming a part of the barnacle belt.

1. INTRODUCTION

The salient feature of the Chilean coastline is its great length, extending from the Subantarctic region at Cape Horn (lat. 55° 58′) through a distance of over 2,600 miles to the Tropics at Arica (lat. 18° 20′ S.). The nature of the coastline changes several times within this distance. In the south the coast is exposed to extremely heavy wave action, but numerous islands give local sheltered conditions. This type of coast is replaced at Chiloë Is. (lat. 42° S.) by an exposed coast with few sheltered bays but with rocky headlands and surf beaches. The rainfall gradually diminishes towards the north and the beaches become smaller and less frequent until the desert coast is reached in about lat. 30° S.

Several expeditions have made brief calls along the Chilean coast to make collections and these have been described in the various reports of the expeditions concerned. However, it is still true to say that the standard reference work for Chilean zoology is Gay's (1847) History of Chile. As recently as 1953 Ekman pointed out that there is a very poor literature from Chile and that the faunal changes are insufficiently recorded.

A start has been made in recent years on the systematics of the Chilean fauna. Yanez (1949a and b) has reviewed the marine birds of Chile and Riveros (1950, 1951) has catalogued two families of molluscs. The algae are not being ignored, as Etcheverry (1955) lists the species found on a restricted part of the Chilean coast and gives general notes on the distribution of the species. The Lund University Expedition to Chile is the most important marine expedition to visit Chile, the collections being made on most of the accessible parts of the Chilean coast, but with particular reference to the south. The reports of the expedition, which are now appearing, will do much to extend our knowledge of Chilean zoology.

This paper is concerned with the survey of the major ecological features of a restricted part of the Chilean coast and is the first of a series of three papers dealing with the important zonal features of that coastline. One of the later papers will describe the zonation encountered on other restricted parts of the Chilean coast and the final paper will compare the conditions found over all of the northern parts of that coast betwen latitudes 35° S. and 18° S. In all of these papers, partly in the interests of space, non-zonal organisms will be dealt with only in a general fashion, but their ecology will form the topic of the final paper.

Since the systematics of the Chilean marine fauna is so poorly understood, it follows that the distribution of many of the marine animals is not known. This lack of knowledge may be extended to include all aspects of marine ecology in Chile, and there is no literature dealing with the ecology of any one intertidal area. There are several papers dealing with the bio-geography of the Chilean coasts in the widest sense and these will be discussed in the relevant paper.

2. NOMENCLATURE

The nomenclature used is that of Stephenson and Stephenson (1949) and Guiler (1953). The author of each species is cited only once.

3. GEOGRAPHIC LOCATION AND TOPOGRAPHY

Montemar, approximate latitude 32° 57′ S., longitude 71° 33′ W., is situated on the west coast of South America some sixteen kilometres to the north of Valparaiso. It is the site of the Marine Station of the University of Chile. Montemar is a small seaside resort, but has the disadvantage that there is a considerable influx of daily visitors in the summer.

The Marine Station is situated on a small point which is exposed to the full effect of the oceanic swell and sea breezes. The coastline to the north is rocky, but to the south, towards Valparaiso, there are several sandy beaches of varying extent. However, the effect of sand scouring at Montemar can be regarded as minimal.

4. METHODS

Collections were made at various places on the rocks at different levels of the shore in the immediate vicinity of the Marine Station. The specimens were provisionally identified and samples were sent to systematic experts for determination. Comparative examinations were carried out on the shore both to the north and the south of Montemar.

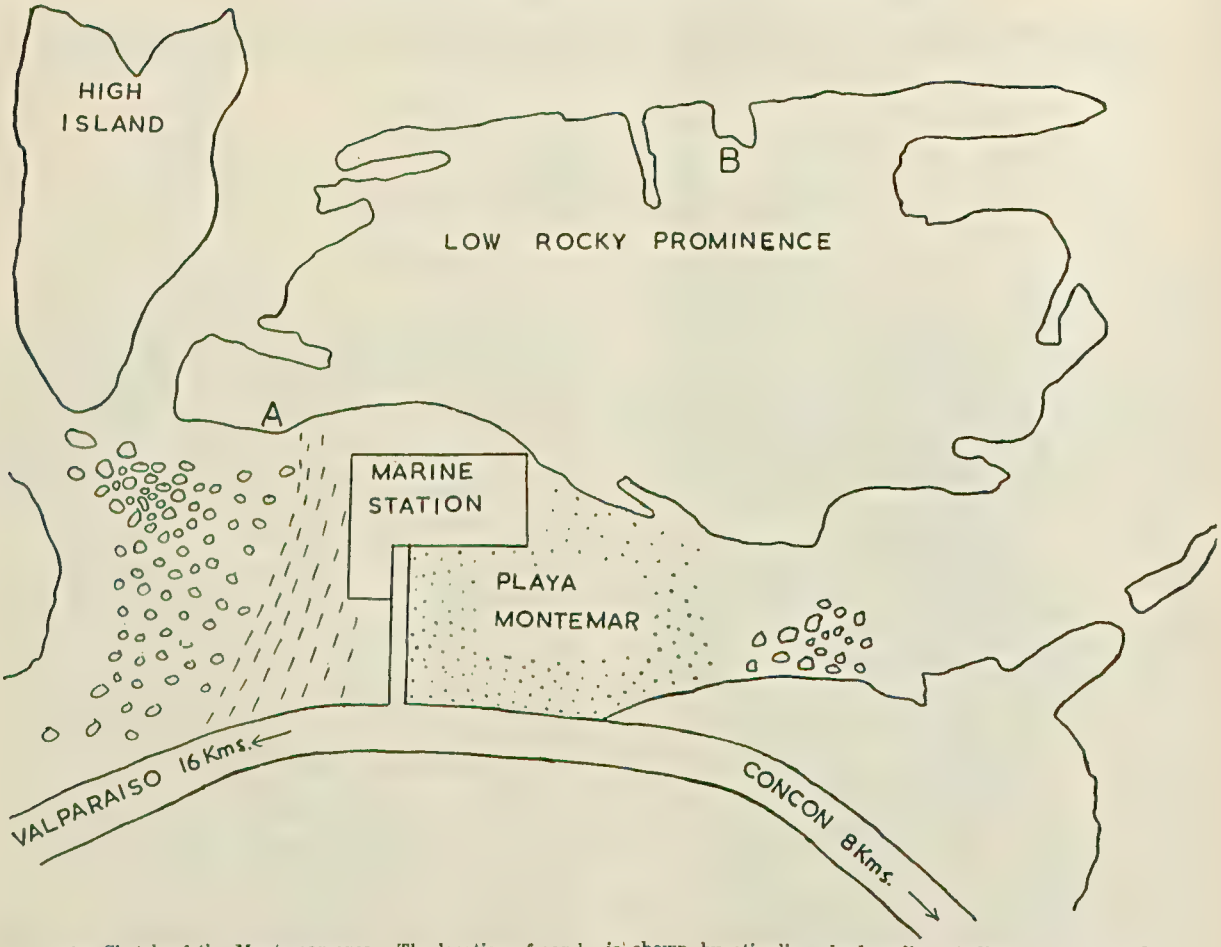

FIG. 1.—Sketch of the Montemar area. The location of sand is shown by stippling, broken lines indicate coarse sand, while gravel and boulders are shown by circles. The letters A and B show the position of the exposed and sheltered transects.

5. TIDAL DATA

Details of the tides, based on actual recorded data, are not available and the only information which I have been able to obtain are the tidal tables prepared by the Chilean Navy (1954). The Lund University Expedition made tidal observations at all their collecting stations and the leaders of the expedition point out that errors exist in the predictions prepared by the Navy and that these errors are greatest in the south (Brattstrom and Dahl, 1951). However, in the absence of any data, I have used the predictions as prepared by the Chilean Navy, but the reader must bear in mind that these figures may be subject to a small error.

The tidal datum line is a level established at Valparaiso and is 0.9 metres below mean sea level.

The tides show the typical oceanic form (fig. 2) and I propose to follow Chapman (1938) and call the tides "high high", "high low" and "low low". Terms widely used in many countries, both in Europe and elsewhere, are all related to certain tidal levels, e.g., mean high water springs. Zanefeld (1937) recognized no fewer than 10 different tidal levels covering a total tidal range of 2.56 metres. This principal is one which is followed in most countries where there is a large tidal range.

In Chile and certain other countries there is a small tidal range. The effects of barometric pressure and prevailing winds are relatively great and it is not possible to recognize, with certainty, any other than the four basic levels noted above. Further, on coasts which are exposed to very heavy wave action, such as much of the Chilean coastline, there appears to me to be little point in attempting to recognize many tidal levels since the spray and wave action factors make detailed tidal calculations somewhat inaccurate and meaningless.

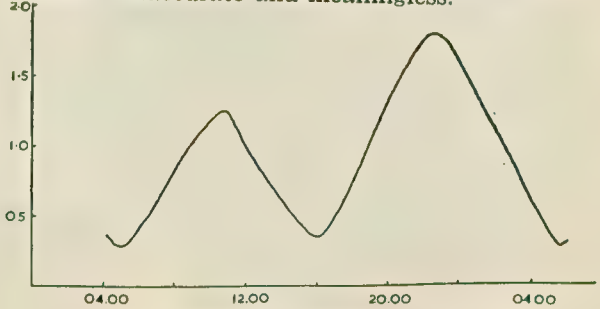

FIG. 2.—Typical tidal curve at Valparaiso for a 24-hour period. The height of the sea is shown in metres above the datum line.

TABLE 1.—*Tidal Data calculated from the Tide Tables published by the Chilean Navy* (1954). *The heights are expressed in metres above Chart Datum. The Abbreviations used are H.H.W., high high water; L.H.W., low high water; H.L.W., high low water; L.L.W., low low water; M.S.L., mean sea level.*

Average Monthly Data during 1954.

H.H.W.	1.58	1.56	1.53	1.50	1.53	1.56	1.56	1.51	1.48	1.49	1.53	1.60
L.H.W.	1.18	1.25	1.24	1.22	1.16	1.13	1.16	1.20	1.23	1.18	1.15	1.16
H.L.W.	0.54	0.52	0.50	0.47	0.47	0.48	0.49	0.48	0.47	0.48	0.49	0.52
L.L.W.	0.45	0.45	0.43	0.39	0.36	0.37	0.38	0.40	0.39	0.38	0.37	0.39
M.S.L.	0.937	0.945	0.925	0.895	0.88	0.885	0.897	0.897	0.892	0.882	0.885	0.942
Greater Rise	1.13	1.07	1.07	1.04	1.80	1.12	1.10	1.06	1.02	1.04	1.07	1.10
Lesser Rise	0.70	0.78	0.80	0.85	0.79	0.73	0.73	0.78	0.83	0.76	0.75	0.72
Greater Fall	1.08	1.12	1.08	1.13	1.17	1.18	1.13	1.11	1.08	1.09	1.13	1.11
Lesser Fall	0.65	0.75	0.72	0.76	0.71	0.66	0.68	0.75	0.79	0.70	0.69	0.65

Mean Annual M.S.L. .... 0.905.

The average heights of the tides have been calculated from the figures given in Chilean Navy Tide Tables and are shown in Table 1. In this Table the expressions "greater rise, lesser rise, greater fall and lesser fall" are used. Reference to figure 2 shows that there are two high tides during a tidal day. Each of these tides rises by a different height from a different level than the other. The maximum rise is called the greater rise and the other is known as the lesser rise. The meaning of greater and lesser fall is derived by the same method. The figures given in Table 1 are graphed on Figures 3 and 4.

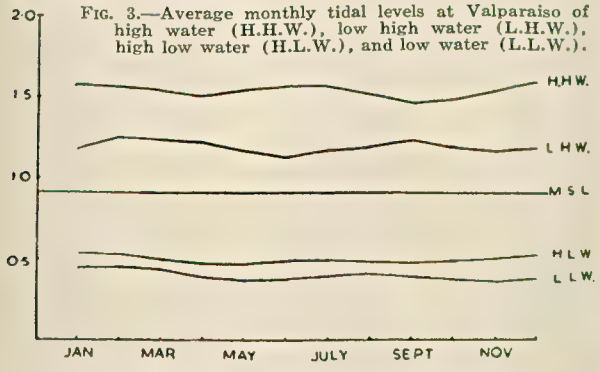

FIG. 3.—Average monthly tidal levels at Valparaiso of high water (H.H.W.), low high water (L.H.W.), high low water (H.L.W.), and low water (L.L.W.).

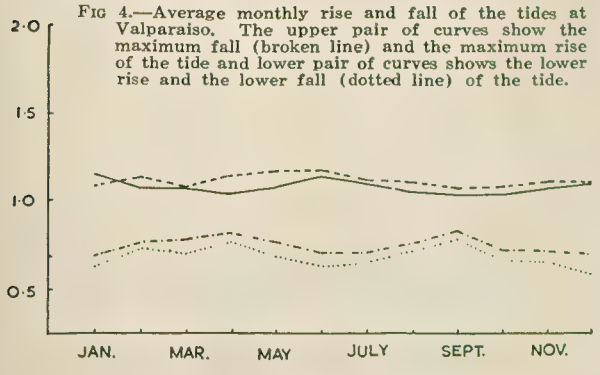

FIG 4.—Average monthly rise and fall of the tides at Valparaiso. The upper pair of curves show the maximum fall (broken line) and the maximum rise of the tide and lower pair of curves shows the lower rise and the lower fall (dotted line) of the tide.

The effect of the tides as an ecological factor has not been examined in detail by any of the few workers who have, to date, worked on the shores of Chile. Studies on the effect of the rise and fall of the tides on intertidal organisms have been carried out in many countries and, although this is not the place to review this work, it is necessary to draw attention to the work of Colman (1933), who stressed the importance of "critical levels" at which the number of species found on the shore changes sharpiy. Many papers have been published since Colman's work, all of the later workers finding an exposure curve which is similar in form to that described by Colman. Doty (1946), applying Colman's technique to tides exhibiting diurnal inequality found that at certain levels on the shore there were sudden increases in the time per day that organisms were exposed to the atmosphere. Guiler (1948), working in Tasmania, noted a sudden decrease in the number of species occurring at these levels and proposed that these levels be known as "lethal" levels. In this paper I have noted that the effect of low tidal amplitudes on the appearance of the shore is not only to lessen the vertical range of the organisms but also to give the shore a very bare appearance above mean sea level. On places which are exposed to heavy wave action the intertidal population has a greatly increased range of vertical distribution and this may rather obscure the bare appearance of the upper shore. The tides in Tasmania are semi-diurnal in nature, but this observation can be held to be true for Chile, where the tides are of the same behaviour. The mean annual tide amplitude at Montemar is 0.92 metres.

The exposure curve for each month of a twelve-month period has been calculated. The number of hours that certain levels of the shore were exposed per month was obtained graphically and these figures, expressed as a percentage, were plotted against Chart Datum level giving the graphs shown in Figures 5 to 16. These graphs show the considerable difference each month in the percentage exposure at any one level on the shore, e.g., at a height on the shore 1.0 metres above Chart Datum the percentage exposure ranges from 53% in

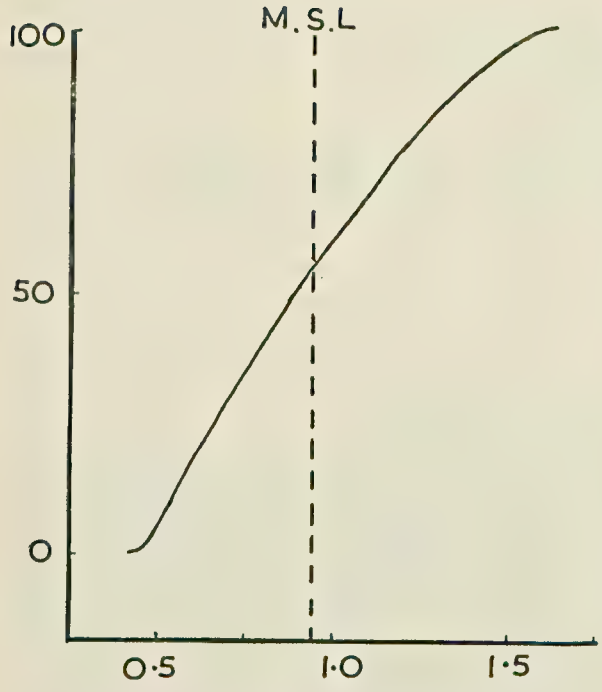

FIG. 5.—Percentage exposure to the air at different levels on the shore at Montemar in January.

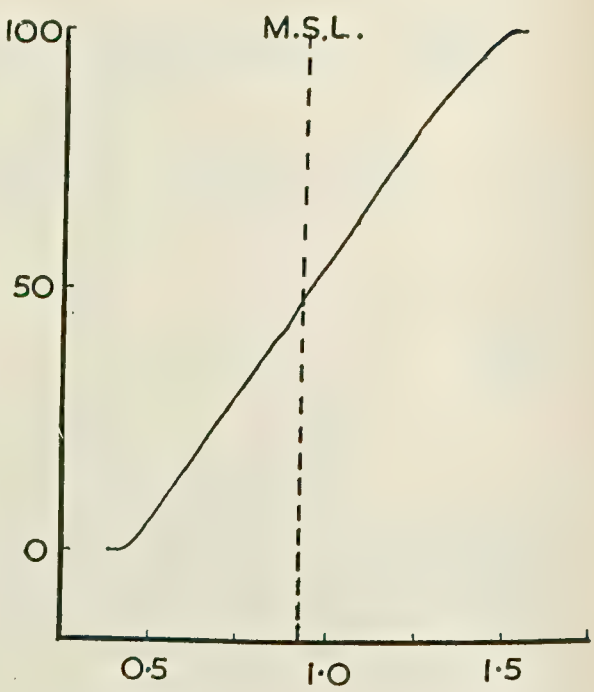

FIG. 7.—Percentage exposure to the air at different levels on the shore at Montemar in March.

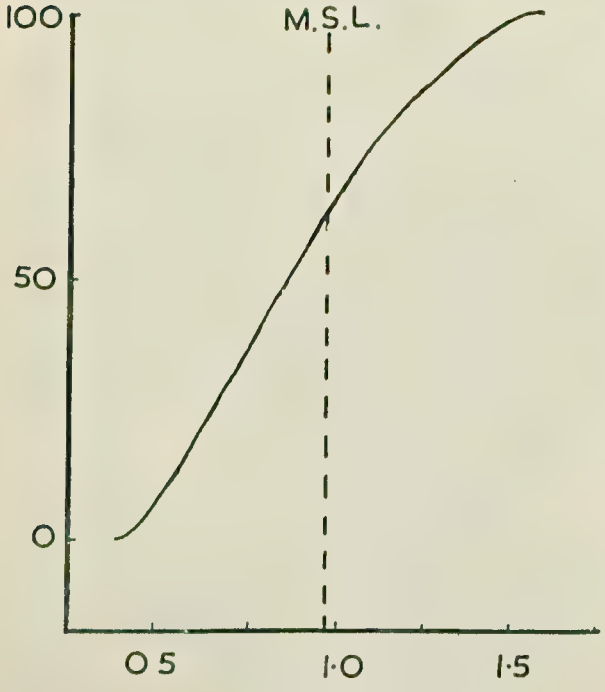

FIG. 6.—Percentage exposure to the air at different levels on the shore at Montemar in February.

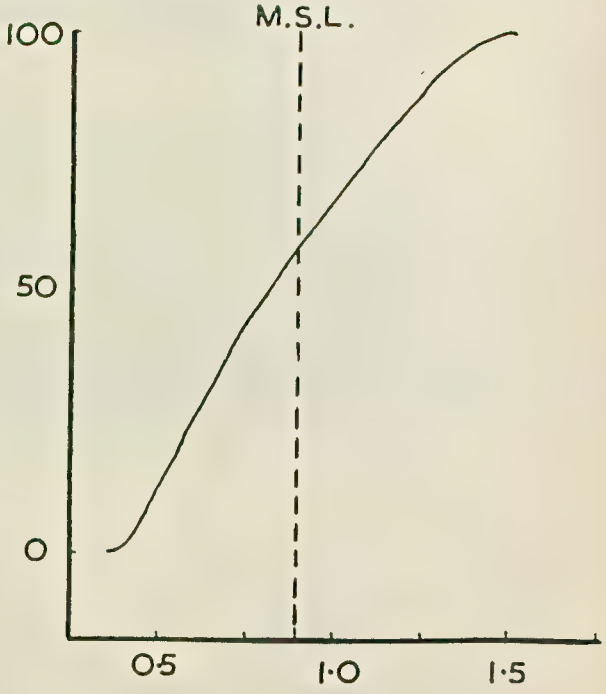

FIG. 8.—Percentage exposure to the air at different levels on the shore at Montemar in April.

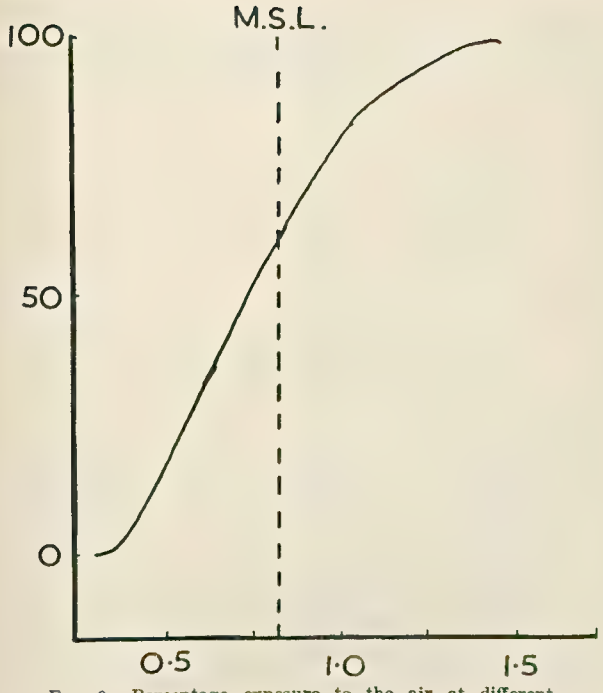

FIG. 9.—Percentage exposure to the air at different levels on the shore at Montemar in May.

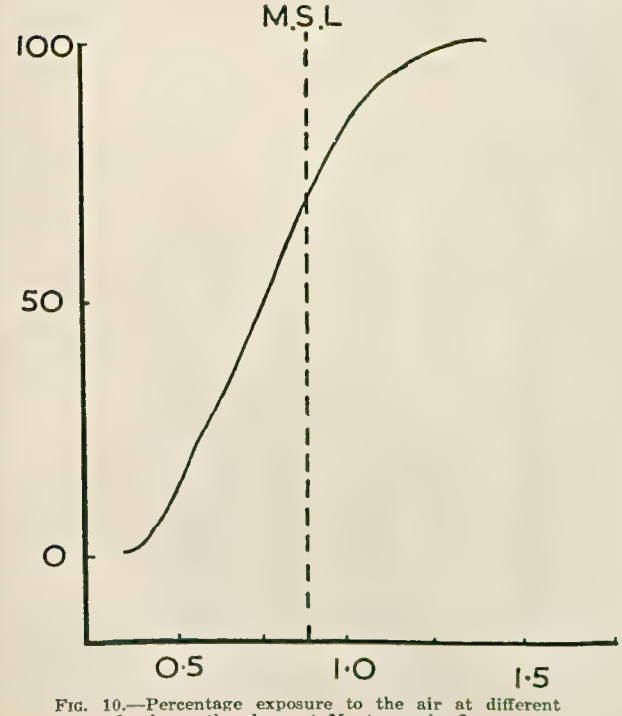

FIG. 10.—Percentage exposure to the air at different levels on the shore at Montemar in June.

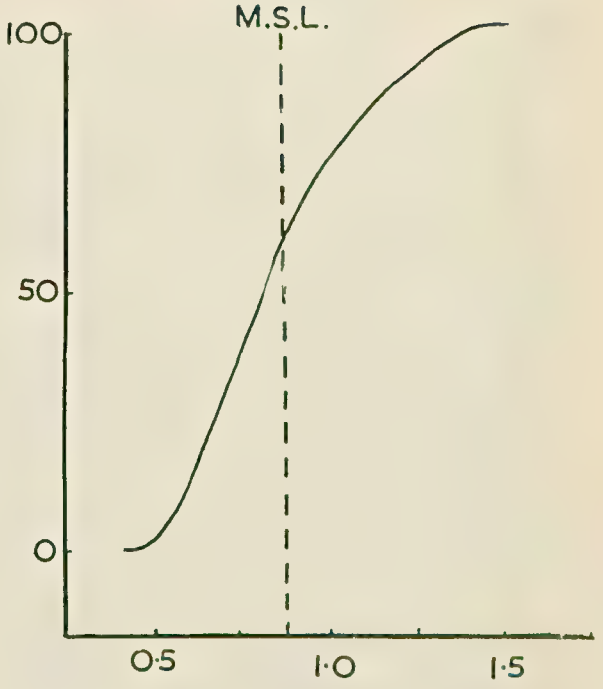

FIG. 11.—Percentage exposure to the air at different levels on the shore at Montemar in July.

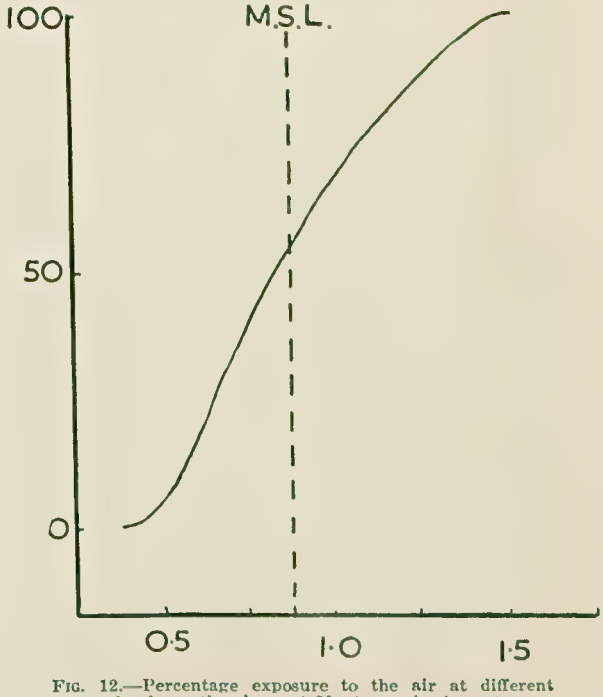

FIG. 12.—Percentage exposure to the air at different levels on the shore at Montemar in August.

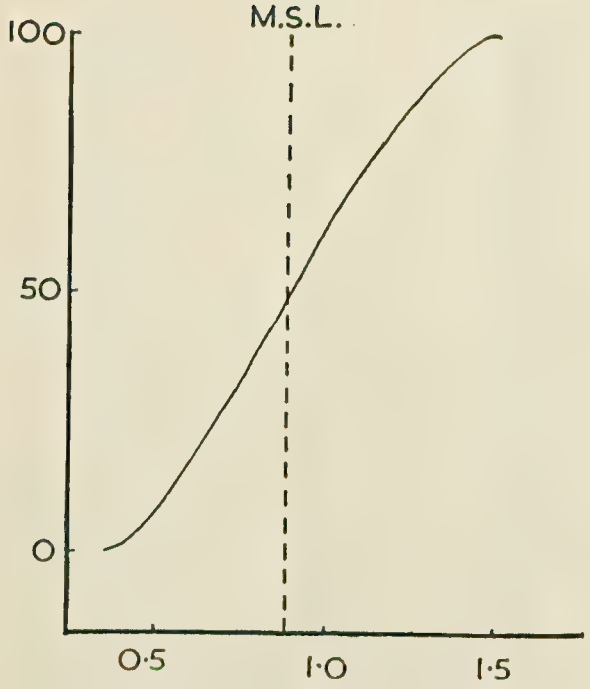

FIG. 13.—Percentage exposure to the air at different levels on the shore at Montemar in September.

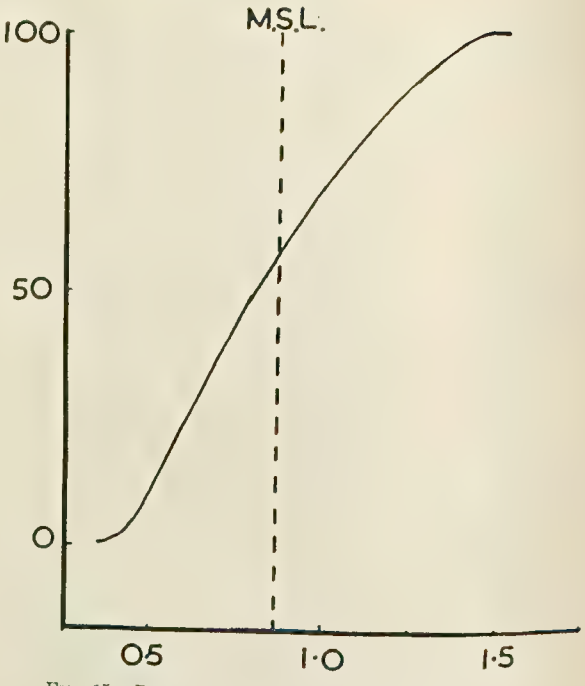

FIG. 15.—Percentage exposure to the air at different levels on the shore at Montemar in November.

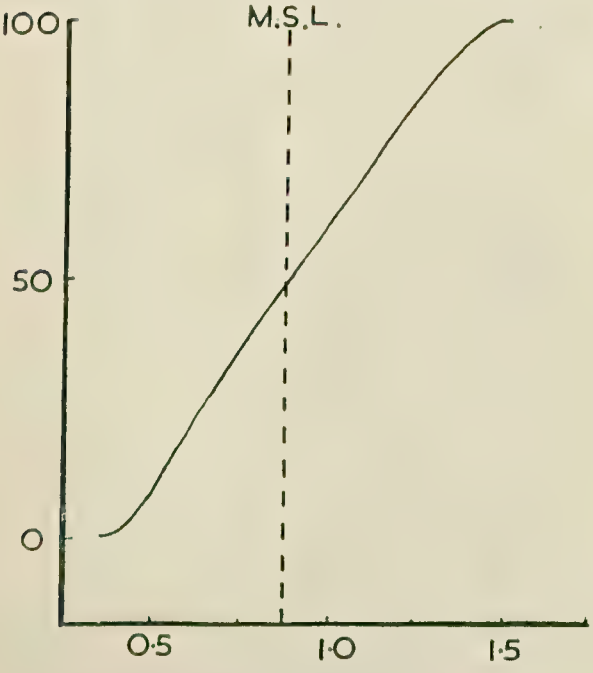

FIG. 14.—Percentage exposure to the air at different levels on the shore at Montemar in October.

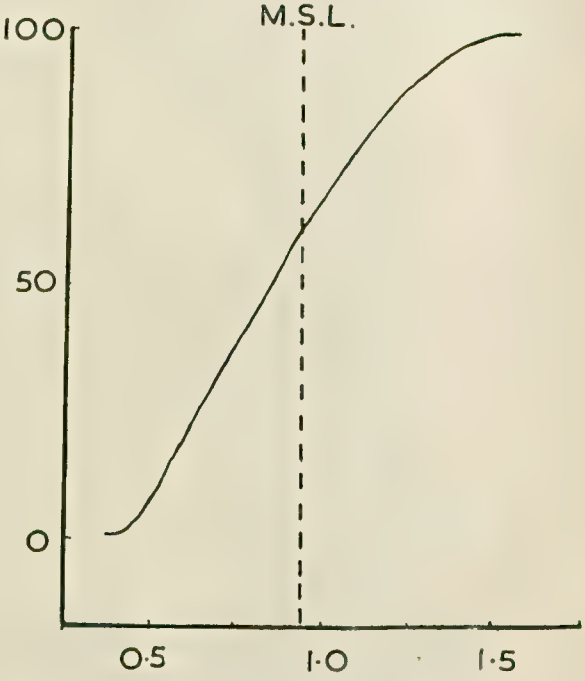

FIG. 14.—Percentage exposure to the air at different levels on the shore at Montemar in December.

February to 82% in May. It is also found that the monthly Mean Sea Level (M.S.L.) also varies in its position on the shore (Fig. 17) and the Mean Sea Level is at its highest and lowest levels respectively during these two months.

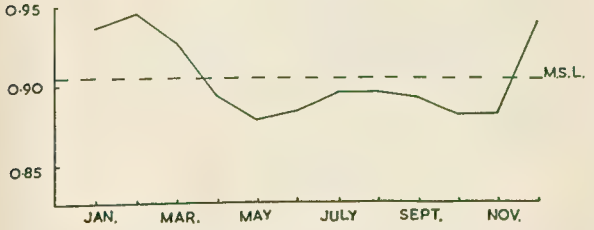

FIG. 17.—Monthly variations in Mean Sea Level at Valparaiso. The mean annual sea level is shown as a broken line.

Patullo, et al (1955), found that the seasonal oscillation in sea level on the Chilean coast departs from the estimated monthly mean by as much as 5 cm. with a standard deviation of 1.0-1.2 cm. Between January and June the level is higher than estimated and for the remainder of the year the levels are lower (fig. 17). The coastline which is being examined is very exposed and a difference of 5 cm. in the level of the sea is not significant in determining the zonal pattern, particularly when, as at Montemar, the wave action causes spray to splash on rocks 20 metres above sea level. For the purpose of the present study, there is little practical point in correcting for this error.

6. OCEANOGRAPHICAL AND HYDROLOGICAL DATA

A brief examination of a chart of the Chilean coast north of Chiloë Island (lat. 42° S.) shows the almost complete absence of a Continental Shelf, though there is a narrow shelf of shallow water, usually 10-15 kilometres in width, but rarely more than 30 kilometres wide. The 200 metre contour passes close to Point Curuamilla, south of Valparaiso, while the 1,000 metre contour is some 20 kilometres offshore. The Fosse de Haeckel, 5,600 metres in depth, is about 100 kilometres to the west of Valparaiso.

The absence of a Continental Shelf is reflected in the amount of heavy and continuous wave action encountered on the coast. The prevailing winds are on-shore, so there is no respite from the incessant battering received from the waves. Although continuous, the wave action in the Montemar area is not as heavy as that encountered in some other coasts in the southern hemisphere, but is heavy enough to render collecting in the Infralittoral Fringe a hazardous and wet business. It is possible only to collect in this belt when low water spring tides combine with the minimum of wave action. It is worth noting that there are no beds of *Macrocystis* to diminish the effect of the waves.

(1) *Sea Temperatures*

Graphs of the sea temperatures at Montemar were published by Cubillos (1955). I am indebted to Sra. Cubillos for the information upon which her temperature graphs were based (Table 2).

TABLE 2.—*Mean Monthly Superficial Sea Temperatures (in degrees Centigrade) at Montemar for the Period May,* 1947, *to August,* 1954.

	Time	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1947	08.00					11.89	12.23	11.95	11.85	11.49	11.81	12.77	12.86
	20.00					12.15	12.36	11.93	12.17	11.58	12.47	13.04	12.70
	Mean					12.02	12.29	11.94	12.01	11.53	12.14	12.90	12.75
1948	08.00	14.45	13.77	13.66	12.71	12.78	12.04	11.90	10.75	11.99	12.78	12.84	14.59
	20.00	14.33	14.22	13.97	12.98	12.94	12.10	12.20	11.36	12.28	13.53	13.40	15.67
	Mean	14.39	13.99	13.81	12.84	12.86	12.07	12.05	11.05	12.13	13.15	13.12	15.13
1949	08.00	16.05	16.24	13.22	13.16	13.03	12.15	11.13	11.32	11.50	12.49	13.20	14.56
	20.00	17.88	17.09	13.85	13.46	13.47	12.36	12.24	11.91	12.32	13.52	13.00	15.41
	Mean	16.96	16.66	13.53	13.31	13.25	12.25	11.68	11.61	11.91	12.95	13.10	14.98
1950	08.00	16.00	14.40	13.75	13.38	12.52	12.74	12.26	11.16	12.30	12.20	13.33	13.64
	20.00	16.95	14.93	14.59	14.69	13.00	13.15	13.00	12.34	13.79	13.39	15.16	15.96
	Mean	16.47	14.66	14.17	14.03	12.71	12.94	12.63	11.75	13.04	12.79	14.24	14.80
1951	08.00	14.75	13.97	12.98	13.32	13.23	12.29	13.40	12.20	11.69	12.24	13.04	15.05
	20.00	16.98	17.80	15.40	14.88	14.87	13.34	14.20	13.57	13.86	14.05	13.89	15.74
	Mean	15.86	15.88	14.19	14.10	14.05	12.81	13.80	12.88	12.77	13.14	13.46	15.39
1952	08.00	16.47	15.77	13.99	13.20	13.86	11.70	11.75	11.70	12.30	12.60	13.60	14.87
	20.00	17.37	16.58	14.62	14.20	14.30	12.04	12.30	12.20	12.79	13.60	15.16	15.89
	Mean	16.92	16.17	14.30	13.70	14.08	11.87	12.02	11.95	12.54	13.10	14.38	15.38
1953	08.00	15.35							11.60	12.48	11.40	12.60	14.26
	20.00	16.70							12.04	13.08	12.20	14.26	15.75
	Mean	16.02							11.82	12.78	11.80	13.43	15.00
1954	08.00	13.10	14.10	14.00	12.75	12.00	12.40	11.56	11.41				
	20.00	15.72	15.90	15.67	13.96	12.50	12.86	12.15	12.23				
	Mean	14.41	15.00	14.83	13.35	12.25	12.63	11.85	11.82				

During the period May, 1947, to August, 1954, the coldest temperature recorded at 08.00 hours was 8.9° C., and the warmest at the same time of day is 19.4° C. At 20.00 hours the coldest temperature recorded is 9.2° C., and the warmest 20.2° C. The warmest monthly average of the mean daily temperature is 16.96° in January, 1949. The coldest mean monthly average of the mean daily temperatures is 11°55 C. in August, 1948.

Further figures for this part of the coast are available from the U.S. Coast and Geodetic Survey (1952) and comparison of the results from the two sets of observations shows that those taken at Montemar are usually lower than those taken by the Survey at Valparaiso, except in the summer months when they tend to be higher. The differences, of up to 1° C. in magnitude, can be explained by the methods of sampling employed at the two stations. Basically, the methods used at both places are the same, namely a bucket is filled with sea water and the temperature of the water in the bucket is taken with a thermometer. However, at Montemar, the bucket is filled off the rocks beside the place marked B on Fig. 1, whereas the U.S. Coast and Geodetic Survey made their observations on the inshore side of the Moio de Abrigo at Valparaiso, in deep water. The temperatures taken at Montemar are thus subject to the cooling or heating influence of the rocks, while the Valparaiso temperatures are a truer record of the temperature of the sea. However, for the purpose of the present work, the Montemar temperatures are used, being the temperatures actually experienced by intertidal organisms.

7. CLIMATIC DATA

All the information quoted has been kindly supplied to me by the Oficina Meteorologica de Chile.

(*a*) *Temperature*

Temperature records have been made at Valparaiso from 1899 and the mean monthly temperatures are given in Table 3.

TABLE 3.—*Mean Monthly Temperatures in degrees Centigrade at Valparaiso for the Period* 1899-1946.

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
18.0	17.9	16.7	14.9	13.5	12.3	11.8	12.1	12.9	14.1	15.8	17.3

Annual Average Temperature 14.8° C.

The above table shows that the air temperature at Valparaiso is very equable with no great extremes of temperature. The relative humidity is also fairly constant (Table 4).

TABLE 4.—*Mean Monthly Relative Humidity at Valparaiso for the Period* 1899-1946.

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
72%	74%	76%	76%	80%	78%	80%	79%	78%	75%	17%	70%	76%

The rainfall shows a very marked seasonal variation with a maximum in June and the winter months all having considerable rainfall. The summer months are dry with the minimum rainfall occurring in February. These conditions are typical of the Mediterranean type of climate.

It was noted above that the intertidal region at Montemar experiences the greatest air exposure during May. This means that organisms living there are exposed to the second heaviest rainfall of the year (95.4 mms.), a cold temperature and the high relative humidity of 80%. During February, when the air exposures on the shore are at the minimum, the shore-dwelling organisms are protected from the heat (17.9° C.), low humidity (74%) and little rainfall (2.0 mms.). Examination of the tide tables reveals that the "low low" tides during the winter most frequently occur during the period 12.00-23.58 hours which, in itself, acts as a further protection for shore-living forms, since they are not exposed to the full effect of cold nights. During the same time of the year the "high high" tide usually occurs between midnight and midday, thus frequently immersing organisms during the coldest part of the day.

In the summer the reverse holds good, the "high high" tide occurring during the midday-midnight period, thus often immersing intertidal organisms during the heat of the day, while "low low" water takes place during the midnight-midday period. Frequently during the summer mornings, the coast is shrouded in mist so that the full effect of the insolation during the "low low" tide period may not be felt on the shore.

Comparison Tables 2 and 3 show that with the exception of June, July and August the mean monthly sea temperature is below the mean monthly air temperature. Even during the three months when the air is cooler than the sea, there is less than 1° C. difference between the temperatures of the two media. In other words, the greatest cold to which intertidal organisms are liable to be exposed is that of the sea.

It has already been deduced that the air exposure in winter and atmospheric conditions combine to give animals and plants living on the shore the maximum protection from climatic factors. It would thus appear that the minimum sea temperatures play the more important part in the distribution of intertidal plants and animals during the winter.

In the summer the continuous wave action keeps the lower tidal belts cool and wet but the upper shore levels can become very hot. The extreme of this is to be seen on a very hot day when spray falls on the highest parts of the shore and steam forms from the very rapid evaporation of the

water. As will be seen later, there are very few organisms inhabiting this part of the shore and these few are all well adapted against the heat or cold so that it can be said that, with the possible exception of the upper part of the shore, sea temperatures in summer are again the controlling factor.

In general, it can be concluded that the sea temperature is very important in controlling the distribution of the intertidal organisms at Montemar and they outweigh the atmospheric factors in importance. However, it must be remembered that the effects of extremes of climate may be locally catastrophic to intertidal animals and plants.

8. ZONATION AT MONTEMAR

The zonation of the exposed rocks at Montemar is as shown below.

Situation: On sloping dolerite rocks N.E. of Marine Station.

Supralittoral:
Usually bare, often with bird excreta.

Supralittoral Fringe:
Vacant.

Midlittoral:
Chthamalus cirratus.
Chthamalus cirratus + *Porphyra columbina* Mont.
Littorina peruviana.
Chthamalus + *Porphyra columbina* Mont.
B. laevis laevis + *B. flosculus* + *Chthamalus.*
Iridaea laminarioides Bory + *Brachidontes purpuratus* Lam. + *Ulva lactuca* L.
Centroceras clavulatum (C. Ag.) Mont. + *Corallina chilensis* Dec. + *Gelidium filicinum* Bory.

Infralittoral Fringe:
Lessonia nigrescens Bory with a few *Durvillea antarctica* (Cham.) Hariot.
? *Lithothamnia.*

As is usual on these coasts which experience heavy wave action, it is difficult to decide on the lower limits of the Midlittoral. At low tide the *Lessonia* belt is always exposed but it is constantly inundated by waves and surf. However, the level of low water as calculated from the available data occurs below the level of *Lessonia*, thus showing that the *Lessonia* belt is in the Infralittoral Fringe.

The next lowest belt, that of *Lithothamnion*-like weeds, can more likely be included in the Infralittoral zone. The rocks are covered by these algae but they are only exposed in the trough of the swell. The *Lithothamnia* do extend into the Infralittoral Fringe where they grow around the holdfasts of *Lessonia*, but they are very soon replaced either by other weeds or by the very dense growth of *Lessonia*.

At low water of very low spring tides there is no doubt that the *Lithothamnion* belt is exposed. During periods when there is a minimum of swell, the *Lithothamnion* belt is exposed for periods of up to minutes at a time but the belt is always inundated before becoming dry. If it were not for this inundation it is unlikely that the *Lithothamnia* would survive for long. It is on sheltered coasts or in sheltered positions that some idea of the true ecological position of these algae can be gained. The *Lithothamnion* belt on a sheltered section at Montemar is found growing at such a level that it is never exposed at low water, thus indicating quite clearly that these algae are of the Infralittoral zone rather than of the Infralittoral Fringe.

The zonation as noted in the table above is very general at Montemar throughout all of the shore where the wave action is strong, except in situations where intense sand scouring takes place. *Iridaea* and the other algae appear to be able to withstand a considerable amount of scouring, but are more critically affected by wave action, since in places they disappear. Where the wave action is diminished they are not replaced by any other algal species.

The vertical heights of the belts at any one place depends entirely on the wave action and the conformity of the rocks at that place. At places where the dolerite has weathered into clefts, the waves here surge back and forth and, consequently, organisms extend far up these clefts. This leads to animals and plants of the Infralittoral Fringe being found very far up the shore.

The relative absence of lichens from this coast is a very surprising feature. The rocks of the Supralittoral are spray swept and one might expect lichens to occur in great numbers, both in species and in individual colonies. However, this is not the case. In places, the rocks are smeared with bird excreta, largely of the gull *Larus dominicanus* Lichtenstein, *Phalacrocarox* spp. and the night-heron *Nycticorax nycticorax obscurus* Bonaparte, and this may act as a limiting factor to the successful spread of lichens. The richest growth of lichen occurs in the northerly, i.e., sun-exposed, aspect of rocks beside the Marine Station. Yet other rocks of similar aspect close by are not populated by lichens. It may well be that the majority of the rocks at Montemar are too near sea level to support a lichen population on account of wave drenching. A small island to which access can be gained at low tide, immediately adjoining the Marine Station, shows very rich lichen growth but at a height considerably above the height of the rocks at Montemar in general. The lichen on this island growes at heights of three metres and more above the highest of the rocks at the Marine Station.

On the rocks, often in places not readily accessible, above the height usually reached by the waves in normal weather, are numerous empty Patelloid shells. These shells are probably collected and brought there by the gull *L. dominicanus*. Matthews (1929) notes the natural food of this species is S. Georgia as "limpets picked off the rocks at low tide". The oyster catcher *Ostralegus ostralegus L.* has been noted by Murphy (1936) as also catching limpets, so that this group of molluscs suffers considerable predation from birds.

THE BARNACLE BELT

This belt is the most extensive on the shore at Montemar. The barnacles are of three species and all are most numerous where surf surges over the rocks, or where the rocks are spray drenched. The density of population of this belt is shown in fig. 18.

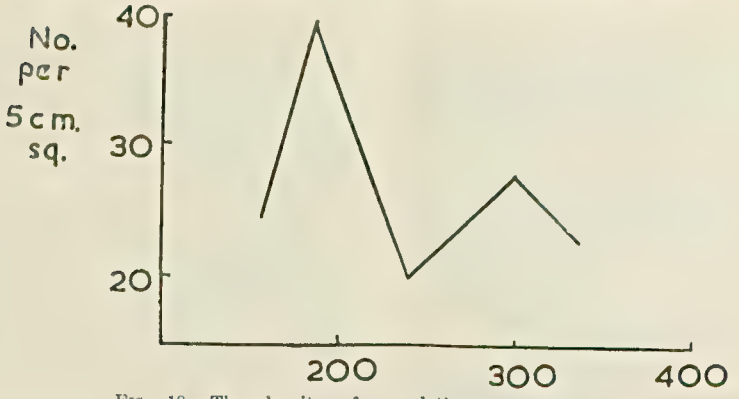

FIG. 18.—The density of population of *Chthamalus cirratus* on the exposed shore at Montemar. The heights are expressed in cms. above M.S.L.

The top of the barnacle belt is occupied by *Chthamalus cirratus* Darwin. This species is easily the most numerous barnacle on the shore, forming dense colonies covering much of the rock surface (Photo 1). The individuals of the species are small in size and form the usual *Chthamalus*-type aggregations.

The barnacles, particularly *Chthamalus*, favour living in the dolerite-granite junction where the rock is much cracked and fissured. Numerous counts and examinations were made in places where the dolerite and granite respectively were populated by barnacles, living at the same height above reference level and with the same sun and wave aspect. It was found that in some places dolerite supported the greater population of cirripedes but in other places the larger number of barnacles lived on the granite. Undoubtedly, the barnacles prefer the rock junction on account of the larger number of clefts which favour larval settlement and also serve to retain water, but beyond that there would appear to be no preference for either type of rock. Visscher (1928) found that cypris larvae were negatively phototropic so that the colour of the rocks, dolerite being darker than granite, may influence the larval settlement.

Included in the barnacle belt are two sub-belts, which may locally form a prominent feature on the shore. The Littorinid belt, populated by *Littorina peruviana* is almost continuous on the shore, though in places where the rock is vertical with little spray, the littorinid population may be so low as to be almost absent. The Littorines favour places where there is heavy and continuous spray (Photo 2) or else where there is residual water, e.g. the dolerite-granite junction where *Littorinas* are numerous together with *Chthamalus*. Around the edges of ponds is another favoured position. *Littorina* seeks sun-sheltered positions and will congregate in greater numbers on rocks with no sun and little spray, than on rocks with more spray but also with more sun.

The *Porphyra* belt, normally occurring below the *Littorina* belt, is sporadic and discontinuous. The alga *P. columbina* Mont. is not very common, and is subject to considerable seasonal fluctuation in density of colonization. The species is most numerous in the spring and early summer when it forms a very well developed band at or near the top of the barnacle belt. The summer sun dries the weed and it is collected by Chileans, who utilise it for food. By the autumn the band is practically non-existent. The seasonal nature of the occurrence of the genus *Porphyra* is well known. This alga, like the mollusc *Littorina peruviana*, also lives around the edges of ponds. In this position in the summer it shows an interesting gradation of colours which reflects the seasonal changes. Early in the spring *Porphyra* is a rich dark purple-brown in colour, and in summer weeds of this colour are to be seen around the top of the pools at water level. As the summer progresses the weed becomes progressively more yellow-brown in colour, eventually becoming a yellow remnant which dries crisp between tides, but recovers on wetting. The various colour stages are to be seen the further away from the pool the weed is found.

The common shore crab, *Leptograpsus variegatus* (Fabr.), lives in clefts in the barnacle belt as well as further up the shore, even extending into the bare rock zone. This species is extremely numerous, and narrow clefts are frequently found to have an unbroken row of *Leptograpsus* living in them. The crabs often come out during the day, moving slowly and cautiously across the rocks. The slightest movement sends them scampering for cover. At night they are easier to capture, especially in ponds. This species has a very wide toleration of stagnant water, as it will readily enter and hide in stagnant ponds half-filled with rotting algae.

In some places, particularly the more sheltered and those where the direct wave action is not too strong, such as the spray zone on exposed rocks, the upper part of the barnacle belt is populated by a tiny red acarine, a *Microtrombidium* sp. In some places this population is very numerous.

The barnacle belt changes in species composition lower down the shore, *Chthamalus* being replaced to a large extent by *Balanus laevis laevis* Brug. and to a much lesser extent by *Balanus flosculus* Darwin. Figure 18 shows the density of population of the barnacle belt at various heights on the shore.

The crevice fauna of the barnacle belt is not numerous in species but there are often considerable numbers of individuals living in clefts. The

crab *L. variegatus*, has been noted above as occurring in the upper part of the belt and the chitons *Chiton cumingsi* Frembly and *Chaetopleura peruviana* (Lam.) form a thick incrustation in clefts in the rocks.

On the shore, the *Iridaea-Brachidontes* belt is the most conspicuous one above the *Lessonia* belt, *Iridaea laminarioides* being a light-greenish yellow in colour. The belt, except in places where it is found in clefts, is not of a great vertical height and it does not occur on parts of the rocks which do not receive considerable wave action. *Iridaea* often uses the valves of the mussel as a substratum. *Ulva lactuca* is also found on this belt, and occurs over most of the shore from the top of the barnacle belt to the lower *Centroceras* belt but it is most common in the *Iridaea-Brachidontes* band. In some places *Ulva* is sufficiently dense to form a band, usually immediately above the *Iridaea*, though this is a very local feature, often associated with surf action.

The *Brachidontes* band is well developed, but the mussels are small in size and do not offer much shelter to other animals. However, in the mussel-*Iridaea* band the number of species found on the shore increases sharply and it continues to increase in the next band, that of the mixed algae of the genera *Centroceras-Gelidium-Corallina*. Etcheverry (1955) records 40 species of algae from these two bands .

Living on the mussels are barnacles, *B. flosculus* Darwin and *Chthamalus scabrosus* Darwin, a small anemone, and several species of limpets. *Porphyra* is very common on the mussels. Living below the mussels are crabs, *Pilumnoides perlatus* (Poepping) and *Acanthocyclus gayi* H. M.-Edw. & Lucas, the worm *Pseudonereis gallapagensis* Kinberg, amphipods, &c. The identity of *Chthamalus scabrosus* is unconfirmed, the specimens being lost in the mail from Chile to Dr. Henry.

The *Centroceras* belt is continuous with the *Iridaea-Brachidontes* belt. The dominant weeds in this belt are *Gelidium filicinum* Bory, *Centroceras clavulatum* (C. Ag.) Mont., *Porphyra columbina*, *Corallina chilensis* Decaisne. These weeds are often attached to *Pyura chilensis* Molina, small individuals of this species often forming densely aggregated sheets on the rocks. *Colpomenia sinuosa* (Roth.) Derby & Sol. is commonly found in this band, as well as in the *Iridaea-Brachidontes* belt, living attached to either the mussels or the rock. The alga also favours ponds on the shore, especially those which receive fresh supplies of surf water.

Limpets of at least four species are found in clefts in this band, accompanied by other species. All places, many of them inaccessible, which are more or less continually deluged with spray, support a number of large limpets of the species *Nacella magellanica*. At no place do these Patelloids form a well-defined belt though they may attain a local dominance on spray-soaked areas. Other smaller species of limpets are found with the large species. These will be described in a later paper dealing with the ecology of special groups.

The cleft fauna of this belt is enriched by the presence of Fissurelids and chitons as well as the limpets noted above. These species are *Fissurella costata* Lesson, *F. crassa* Lam., *Chiton cumingsi*, *C. granosus* Frembly and *C. latus* Sow.

A large chiton, *Enoplochiton niger* Barnes, forms a conspicuous feature on the shore at this level. Although common and large (8 cms. long), this species does not form a belt. This chiton is a dark red-brown colour with the valves often showing heavy erosion. The girdle has sparsely-distributed scales. Individuals of this species may reach as much as 8 cms. in length. Frequently associated with *Enoplochiton* is another chiton, *Acanthopleura echinata* (Barnes). The latter species, although not as numerous as *Enoplochiton*, is more conspicuous on account of the very prominent black girdle which bears a number of strong, projecting spines. *Acanthopleura* is particularly numerous around the holdfasts of *Lessonia* as well as below extreme low water mark. Dall (1909) notes that these two species are characteristic of the Peruvian province. Although the Lund University Expedition found *Acanthopleura* at Montemar, they did not record *Enoplochiton* (Leloup, 1956).

The lowest belt on the shore, the *Lessonia* belt, is wide but difficult to examine on account of the prevalent surf. The *Lessonia* fronds are often very badly battered by the waves and measure less than 0.3 metres in length. Although *Lessonia* is the dominant plant on this part of the shore, scattered individual plants of *Durvillea antarctica* (Cham.) Hariot form a conspicuous feature. The latter species is readily identified, having long fleshy fronds over a metre in length. Even in the most exposed position these fronds are not shortened by wear against the rocks. *Durvillea* is yellowish-brown in colour, which contrasts sharply with the dark chocolate-brown of *Lessonia* (Photos 3 and 4).

Durvillea is harvested by fishermen and by visitors to the beach, the weed being dried in the sun and then sold for human consumption. The continual removal of *Durvillea* cannot fail to affect the numbers of this weed, and under undisturbed conditions it is likely that this species would be of greater ecological significance.

The *Lessonia* belt forms a very suitable habitat for animals, and the fauna found there is varied. Living on the rock between the holdfasts are very large barnacles, *Balanus psittacus* Darwin, and the chitons, *Enoplochiton niger* and *Acanthopleura echinata*. Fissurelids are very common in this belt, the large species, *F. crassa* Lam., being very frequent. *F. crassa*, which often has a small limpet attached to the shell, is also numerous. *Pyura chilensis* is often found in this belt, though it is not continuous around the shore.

A Thaid, *Concholepas concholepas* Bruguiere, is found in clefts in the *Lessonia* belt. This mollusc known as "Loco", is very popular as food and it is extensively hunted. In spite of this predation, the species is common on exposed coasts. Also found in clefts are a thaid, *Thais chocolata* Duclos, *Chiton granosus*, *Fissurella crassa*, *Enoplochiton niger* and *Turbo niger*.

The holdfasts of the weed offer shelter to a number of forms. Prominent amongst these are small crabs, of which there are four species, *Petrolisthes spinifrons* (H. M.-Edw.), *Pachycheles grossimanus*

(Guerin), *Pilumnoides perlatus* (Poepping), and *Taliepus dentatus* (H. M.-Edw.). Adult specimens of *Petrolisthes spinifrons* are found in the weed holdfasts, also the snapping shrimp *Synalpheus spinifrons* (H. M.-Edw.). The "snapping" of this species can be heard at low tide. Small molluscs also frequent the holdfasts. *Pseudonereis gallapagensis* Kinberg is found amongst the roots of the holdfast.

Specimens of the Majid crab, *Pisoides edwardsii* (Bell) can be found crawling among the *Lessonia* fronds. These crabs have a very strong carapace and also have powerful legs so that they can hold very tightly to the weed and withstand wave action. These crabs are parasitized by a leech which lives around the bases of the thoracic appendages. This leech, according to Miss Ingram, may well belong to a new genus.

Two other species of crab lead a roving existence among the *Lessonia* stipes and fronds. These are *Acanthocyclus hassleri* Rathbun and *A. gayi* H.M.-Edw. & Lucas. Both of these species have a very strong calcified integument and can exert a most powerful grip with their claws. Although *A. gayi* was collected on the rock as well as on *Lessonia*, *A. hassleri* was found only on *Lessonia*.

Where the *Lessonia* belt extends into gullies there are species of small algae which form tufts on the rock with limpets. In semi-sheltered places which also receive some sheiter from wave action the alga *Codium dimorphium* Svedeleus forms a thick continuous cover over the rock. This alga grows only on vertical rock faces.

Also found on vertical or steeply-sloping rock faces, particularly in gullies, in the rocks, is a most remarkable fish, *Sicyases sanguineus* Muller & Troschel (Gobiesocidae). This fish clings by means of its ventral sucker to the rock and, where the surf has receded, it can be seen feeding with its incisor teeth on the minute algae growing on the rock. The fish clings on to the rock in spite of the heaviest surf, allowing its tail to swing with the flow of the water. The fish, which is effectively protectively coloured, grows to about 0.4 metres in length and quite large fishes can be seen clinging to the rocks. These fishes can tolerate some insolation, having been seen fully exposed to the summer sun for a period of up to three minutes. When a fish wishes to change position it partially relaxes its sucker and slithers down the rock or else is swims quickly to a new resting place when it is submerged by a wave during the very brief period when the water is nearly stationary before the wave recedes.

The fish is parasitized by a species of leech probably belonging to the genus *Platybdella*, the leeches being found in the operculum and sucker regions. Miss Ingram tells me that neither this leech, nor the one from *Pisoides*, has been recorded previously from South America.

Sicyases is subject to some hunting, being caught with long-handled dip nets. It offers but poor food.

A large actinian, *Phymactis clematis*, M. Edw., is found mainly in this zone. This species occurs in three colour phases, a red, a green, and a bright-blue. The red individuals occur highest on the shore, but still in the Infralittoral Fringe or in ponds, and in light-exposed places. The green specimens are found at slightly lower levels, not in small ponds and in places where there is shelter from the light, while the blue individuals occur in semi-cryptic places with no direct illumination. Often associated with this anemone is a Porcellanid crab, *Petrolisthes angulosus* (Guérin). Also occurring with blue variety of *Phymactis clematis* are the large chitons *Enoplochiton niger* and *Acanthopleura echinata*, the Sagartid, *Sagartia chilensis*, and the echinoid *Loxechinus albus* (Molina).

The echinoid is very common in rock pools of the lower Midlittoral, particularly those which continuously receive surf. In several pools this species is so common that all the algae have been eaten out of the pond. A feature of this browsing is the very sharp cut off of the upper limit of feeding. *Loxechinus* is collected and sold for human consumption. It is parasitized by *Pinnotheres chilensis* M. Edw., the latter species being regarded as an epicurean delight.

The weed, *Chaetomorpha aerea* (Dilwyn) often hangs over the entrance to clefts, forming a thin screen. It also occurs in other semi-cryptic places. *Dendrymenia flabellifolia* (Bory) Skottsb. often forms a thick carpet in sun-shaded places, frequently using *Pyura* as a substratum.

Lessonia is subject to the attacks of a limpet *Scurria scurra* (Lesson). This species burrows into the stipe of the weed, causing a considerable wound (Photo 3) which in time develops into a point of weakness at which the stipe breaks. I have seen stipes which have been broken by this limpet and the limpet has remained on the stipe, forming an apical hollow in which it lives and feeds. Another species of *Scurria* burrows up into the holdfast of *Lessonia*, forming another source of weakness to the wave action. There is a very interesting parallel to this in the stages of *Patina laevis* (L.) attacking *Laminaria digitata* (Huds.) Lamour in the British Isles and Europe. It is worthy of note that the Chilean limpets do not attack *Durvillea*, which grows in amongst the *Lessonia* plants. The ecologically and phylogenetically related *Sarcophycus potatorum* (Labill.) Kutz also is not attacked by limpets in Australia.

The *Lithothamnion* belt is surprisingly devoid of life other than the continuous coating of the algae. Although it has not been possible to collect in this belt, I have been able to observe it closely on many occasions. The chiton *Acanthopleura echinata*, which grows to a length of more than 15 cms., is a most obvious inhabitant of the zone. The population of this species is not dense, one or two individuals being found at about 3 or 4 metres distance apart. The gastropod *Thais chocolata* is also sparsely distributed in the belt, though it is sometimes more numerous than *Turbo niger*. This species is difficult to observe since the shell is often coated with *Lithothamnion*. It usually favours small crevices or niches in the rocks, since it cannot hold on against wave action as strongly as *Thais*. In these places it is sometimes very numerous.

Two asteroids are common in these clefts, namely the large blue *Meyenaster gelatinosus* (Meyer) and *Stichaster striatus* Müller and Troschel.

It is difficult to account for the paucity of numbers of animals in this region of the shore. One might reasonably expect Patelloids, more numerous chitons and some more algae to occur, but they are not present. The most likely reason is that the incessant thrashing of the fronds of *Lessonia* tends to brush away the animals.

ZONATION IN SHELTERED POSITIONS

Since the whole of the coast of Montemar falls into the category of an exposed coast it must be understood that by a sheltered position I mean a place which is sheltered from the main force of the waves. There are no islands or bays which give sheltered waters such as may be encountered in other parts of the world, or on the southern Chilean coast.

Two localities at Montemar are sheltered from the maximum wave action. These are the beach, Playa Montemar to the north-east of the Marine Station, and a beach to the south-west. This latter beach is not as completely sheltered from the waves as is the Playa, the shore hereabouts consisting of shingle and coarse sand with stones in the lower parts of the Midlittoral and the Infralittoral Fringe.

The South-West Beach

The true zonation on most of this beach is obscured because the beach is much broken up by stones, forming ponds and areas of running water. It is possible, however, to obtain a picture of the zonation in the rocks at the western side of the beach.

Substratum: Granite without dolerite dykes.
Zonation:
- Bare rock.
- Barnacles.
- Barnacles + *Mytilus* + very few *Ulva lactuca* plants.
- *Tegula atra* (Lesson) + *Adenocystis utricularis* (Bory) Skottsb.
- *Lessonia nigrescens.*

The zonation is very simple and without any complex variations. The barnacle belt is practically pure, there being very few *Littorina peruviana* present, the few being mostly confined to rock clefts.

The limpets are scarce, being confined to clefts.

Telgula atra is very numerous. The species is most conspicuous against the rock because all the shells are covered with *Lithothamnion.*

The transition from exposed conditions to sheltered is very rapid, occurring as a horizontal distance of less than one metre. The most notable differences from exposed conditions is the very sudden drop in the numbers of animal and plant species and the equally sudden lessening of the vertical height of the zones on the shore. Figure 19 shows the vertical distribution of the principal belt-forming organisms on both exposed and sheltered coasts at Montemar.

In this figure, the point of reference on the shore cannot be that of any intertidal organism, but it must be a tidal level, the height of which it reaches on both types of shore being noted simultaneously. This level was observed and used as the reference point for all measurements. The effect of wave action is shown in the raising of all of the belts of the intertidal region on the exposed shore. It is particularly significant that Mean Sea Level on the exposed coast is below the level of the species normally considered as being characteristic of the Infralittoral Fringe, namely *Lessonia nigrescens.*

The boulder region just below the shingle beach furnishes the richest collecting. Most of the forms are semi-cryptic or cryptic in habit. All of this area is subject to considerable wave action during heavy winter storms and although many of the boulders are very large and have been wedged together by the waves, it is possible to collect the area fairly effectively.

The most noteworthy feature of the fauna dwelling below the boulders is the poverty of the Poriferan fauna. Sponges were not collected anywhere on the exposed coast, except in the "roots" of *Lessonia.* The only sponges collected here were a yellow-coloured *Haliclona sordida* Thiele and *Halichondria panicea* (Pallas). The latter specimen resembles *H. prostrata* Thiele, previously recorded from Tumbes, but the spicules are longer than for *prostrata* and Dr. Burton believes that the specimen can be assigned to *panicea.* Many places which appear to be suitable for colonization by sponges, both on sheltered and exposed coasts, are not populated by representatives of this phylum. *Codium dimorphum,* to some extent, occupies a typical encrusting poriferan habitat.

The snapping shrimp *Synalpheus spinifrons* is common below stones on this part of the shore as is *Betaeus emarginatus* (H. M.-Edw.). The Decapod crustacean fauna on this part of the shore is very rich in numbers and species. The most numerous decapod is the hermit crab *Pagurus edwardsii* (Dana) which lives in the vacated shells of *Tegula* spp. The population of this species often reaches a local density of 5 per cm. square. The asteroid *Patiria chilensis* (Lutken) a small *Patiriella*-like species, is common below stones on this shore.

The Porcellanid *Petrolisthes angulosus* (Guérin) is also very numerous in the typical Porcellanid habitat below loose stones and rocks and *Gaudichaudia gaudichaudii* (H. M.-Edw.) is also numerous living buried in the shingle at low water. This species ranges in colour from brownish-red to a blue-red.

Other common crabs are *Paraxanthus barbiger* (Poepping), *Petrolisthes spinifrons* (H. M.-Edw.), *Pachycheles grossimanus* (Guérin), *Pilumnoides perlatus* (Poepping), *Taliepus dentatus* (H. M.-Edw.), and juvenile *Acanthocyclus gayi.* The Majid *Pisoides edwardsii* is uncommon and is always found crawling in *Lessonia* fronds. *Leptograpsus variegatus* is absent from this part of the shore because the area, having an immersion factor tolerated by this species, is formed of coarse sand unsuited to *Leptograpsus,* which lives on rocky places.

The prawn, *Rhynchocinetes typus* H. M.-Edw., is very common and is found swimming in ponds and still water left among the rocks by the receding tide. These animals are of the common transparent yellow shrimp colour with red and white markings and yellow spots.

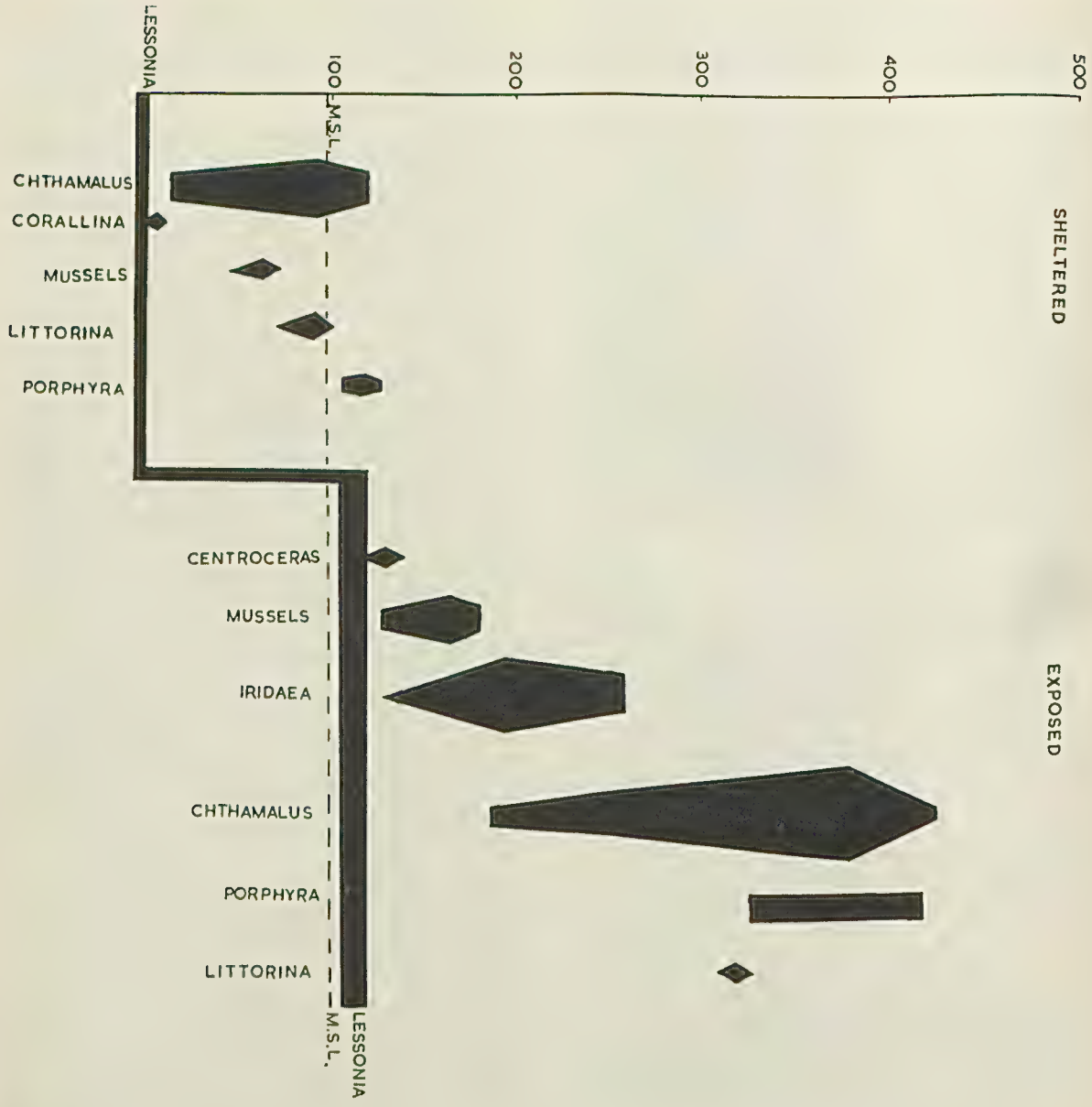

FIG. 19.—The heights of the main intertidal zones on exposed and sheltered shores at Montemar.

Although the fauna and flora of intertidal ponds is outside the scope of this work, there are certain features of the pond habitat which must be mentioned. All the ponds at the high levels of the shore are polluted by decaying debris or by the decaying food left by picnic parties. In spite of what is, in some case, a very high degree of pollution, *Leptograspus variegatus* runs in and out of these ponds.

The ponds at the lower levels on the shore are populated by forms usually found living even further down the shore than the ponds themselves. This generalization is found to be true throughout the region and sometimes this feature is very noticeable so that it is surprising to find *Betaeus emaginatus*, a large olive-brown form, living in considerable numbers in a pond on Concon Island at the level of extreme high water.

The deep ponds are frequented by young fish. The most common of these is the "vieja negra", *Graus negra* Philippi. A small Clinid fish is also frequent. Mann (1952) observes that this family in Chile is very confused and no satisfactory identification could be undertaken.

The sheltered stony shore is primarily occupied by animals, the plants being secondary in importance. The only large plants found are *Lessonia nigrescens, Codium dimorphium, Adenocystis utricularis* (Bory) Skottsberg, *Colpomenia sinuosa* and *Scytosiphon lomentarius* (Lyng.) J. Ag. Although these algae are common, only *Lessonia* is a prominent feature on this part of the shore.

The upper surfaces of the large boulders on the shore are usually fairly densely populated by the barnacle *Chthamalus cirratus*. It is noticeable that the dolerite rocks weather to a more rounded shape than the granite, which always has a rough surface. This rough surface presents a more suitable substratum for the settlement of barnacle larvae and there is a resultingly larger barnacle population on the granite. This is strikingly in contrast to the situation on the exposed shore, where, as noticed above, there appears to be no detectable difference between the populations of the two types of rock.

The rocks are embedded in a shelly sand which shelters numbers of a holothurian. *Meyenaster gelatinosus* is also found below the stones, though it is not embedded in the sand. Certain of the belt-forming algae are subject to seasonal variations in their numbers. *Porphra columbina* has been noted above as being seasonal in occurrence.

Iridaea also shows some degree of seasonal variation. About the middle of January the plants growing in the upper part of the *Iridaea* belt wither, die, and turn white in colour. This part of the *Iridaea* belt then is dominated by barnacles and so becomes the lower part of the barnacle belt.

Ulva also becomes scarcer in the summer, plants in the high rock ponds dying, as do those in the upper parts of the mussel beds.

Similar seasonal variation in *Porphyra* and *Ulva* have been noted in Tasmania (Guiler, 1950).

The area described above is a popular holiday beach, many people spending a day there. It is difficult to assess the damage done to the density of intertidal populations by human interference. Chileans are very fond of seafood and collect considerable numbers of animals and plants from the rocks. The species taken for food are *Ulva lactuca, Porphyra columbina, Durvillea antarctica, Pyura chilensis, Concholepas concholepas, Turbo niger, Teluga,* spp., *Thais chocolata* and the large chitons. *Iridaea* also may be collected, being mistaken for *Porphyra*. With one exception, *Durvillea,* little damage has been done to the main features of the zonation which is the same as that seen along many kilometres of coastline. The possible human effect on the distribution of *Durvillea* is discussed below. The smaller crustacean groups are well represented but have not been collected in any numbers with the exception of the Caprellidae which will be the topic of a separate systematic paper.

The annelids are well represented on this shore, but a surprising feature of the species composition of this phylum on the sheltered beach is the absence of the larger species of Serpulid. *Spirorbis* sp. is present, often coating the underside of rocks or living on the stipes or holdfasts of *Lessonia,* but there are no species of *Galeolaria, Pomatoceros, Pomatoleios* or similar genera.

A sabellarian, *Phragmatopoma moerchi* Kinberg, is very common below stones, living in a tube formed of shingle fragments, usually pieces of mollusc shells. *Potamilla* sp., (Fam. Sabellidae), is frequently encountered living below rocks. Another common species also found below rocks is the tubicolous *Platynereis magalhaensis.* Other species found below rocks are a species of *Euphrosine* (Fam. Sabellidae), *Lumbrineris tetraura* (Schmarda), *Demonax* sp. (Fam. Sabellidae), and a Terebellid *Thelepus concinnatus* (Fabr.).

The dominant fauna living in the sand at the north-eastern end of the rocky area at Montemar is annelidan. Apart from the Anomuran *Emerita analoga* (Stimpson), the only other common macroscopic organisms found are annelids, namely, *Nerides* sp., *Lumbrineris* sp., *Scoloplos* (Leodamos), *ohlini* (Ehlers), *Lumbrineris? tetraura* (Lumbrineridae) (these last two species being extremely common), *Marphysa? sanguinea* (Eunicidae) *Hemipodus simplex* (Grube) (Glyceridae) *Cirriformia* sp. (Cirratulidae) and a Spionid. All of these species are very common in sand washings obtained at low water level.

9. COMPARISON WITH NEARBY AREAS

(a) Laguna Verde and Pt. Curaumilla

Twenty-two kilometres to the south of Valparaiso there is a beach known as Laguna Verde. This beach is not a very widely used holiday resort and so the zonation there is less spoilt by human interference. Point Curaumilla is ten kilometres further south than Laguna Verde and is only accessible by walking or by transport over a very rough road.

The beach at Laguna Verde is about one mile in length with an electricity power station at the southern end, followed by a rocky coastline. At the northern end of the beach the shore line changes abruptly to high vertical cliffs.

(i) *The Zonation at the Northern End of the Beach*

Due to the topography of the coastline it is not possible to carry out examinations of much of the shore hereabouts. However, examination of the accessible area did show some important variations from the zonation at Montemar.

The most significant feature is that *Littorina peruviana* forms the highest belt on the shore. This is in accordance with the expected littorinid habitat in other parts of the temperate and even semi-tropical regions of the world, where one species or another of this family forms the first belt of marine organisms encountered below the trrestrial realms.

The littorinid belt is replaced by a *Porphyra* belt which, in turn, is replaced by *Iridaea.* The latter is followed by the *Centroceras-Gelidium-Corallina* belt. The surprising feature is the complete absence of barnacles, *Chthamalus cirratus.* This species does not form a belt nor does it occ[illegible]

as individuals. The absence of the barnacles is associated with the intense sand scouring.

There may well be seasonal variation in the form of the zonation. The above condition was observed in February and March.

It was noted on a later visit to this beach that the level of the coarse sand on the rocks had fallen about 5 cms. In spite of the heavy scouring which must take place during the sand movement, *Lessonia*, *Porphyra* and *Iridaea* were still present on the rocks and showed little apparent effects.

Movements of sand will, of course, have some effect on the organisms which live in the sand, though these creatures are usually fairly mobile and, unless storm conditions prevail, can usually look after themselves. The organisms living on nearby rocks must, to survive, be able to withstand periodical burial under sand for varying periods.

Below the mixed algal belt is the conspicuous *Lessonia nigrescens*, with which are associated *Lithothamnia* and *Pyura*. *Acanthopleura* and *Enoplochiton* do not occur in places where there is strong sand scouring.

In this place there are very few limpets, only one species being there.

(*ii*) *At the Southern End of the Bay on the Rocks Beyond the Power Station*

The zonation here is strikingly different from that seen at the northern end of the bay. The littorinid belt is still found and the barnacle belt is absent, *Porphyra* and *Iridaea* being the zonal organisms in this part of the shore.

The *Centroceras-Geldidium* belt is also absent, being replaced by an *Ahnfeltia durvillaei* (Borg.) J. Ag.-*Gymnongrus-Laurencia chilensis* Forti and Howe association with *Dendrymenia flabellifolia* (Bory) Skottsb. in sun-shaded places. This is, in turn, replaced, though in shaded places it is overlapped by a very rich *Codium dimorphum* belt, by *Lithothamnion* at the lowest tidal levels.

The most striking feature is, of course, the absence of either of the large Phaeophyceae, *Durvillea* or *Lessonia*. Other species which are characteristic of the Phaeophycean zone are present, e.g., *Acanthopleura echinata* and *Turbo niger*. This feature, combined with the changed species composition and slightly modified appearance of the algal belt immediately above it, makes the shore most strikingly different from any other part of the coast.

About one kilometre to the south of the Power Station the zonation changes sharply, the upper parts of the shore returning to a condition more resembling that at Montemar. The littorinid belt is present and quite well developed, the barnacle belt is present, and so is the *Centroceras-Gelidium* belt. However, in the Infralittoral Fringe the *Lessonia* belt is replaced by a belt of pure *Durvillea antarctica*. *Lessonia nigrescens* is present in slightly sheltered positions in this area. It is found living in places which suffer from slightly less to considerably less wave action than those situations occupied by *Durvillea*. *Lessonia* plants collected here show a considerable difference in form from those found on exposed shores, the stipe being very short and the fronds broader. (Photo 5). The identity of a specimen of this alga was kindly checked for me by Professor Etcheverry.

Durvillea becomes very common towards Point Curaumilla and completely replaces *Lessonia* on this coastline, but only in places where there is considerable wave action. In more sheltered places *Lessonia* is still the dominant alga of the Infralittoral Fringe. In some places *Lessonia* forms beds on rocks in shallow water in sheltered inlets similar to those formed by *Macrcystis* (see below). These beds must exert a considerable effect in lowering the strength of wave action and in forming a shelter for other forms.

To the south of Point Curaumilla the dominant alga is again *Durvillea*.

The full significance of the change in zonal species is apparent whenever the distribution of *Durvillea* is considered in relation to wave exposure. This alga occurs on the southern side of Point Curaumilla as well as on the more exposed places on the northern side of the Point. The prevailing swell is from the south-west so that it is obvious that this alga has a very strong preference for places of strong wave action. At Las Ventanas, to the north of Montemar, *Durvillea* almost reaches the status of the dominant species in places where the wave action is most strong. At Pichidanqui, however, *Lessonia* is the dominant species and also at Coquimbo.

Why, then, is this species almost absent from the Laguna Verde-Montemar-Quintero area? Is it possible that Point Curaumilla acts as a breakwater and diminishes the waves to such an extent that Durvillea cannot flourish until Ventanas is reached? This hypothesis can hardly be held correct, since the wave action on the sheltered northern side of Point Curaumilla is appreciably less than at Montemar, even allowing for "bending" of the swell around the point.

The influence of fresh water throughout this area is negligible though it can have important local effects as at Concon (p. 181). In general, however, this part of the coast can be considered to be washed by the same type of water as the areas immediately to the north and south.

The only factor which offers any explanation of this peculiarity in the distribution of *Durvillea* is the effect of human interference. As noted above, *Durvillea* is in considerable demand for food. It is collected by fishermen, dried and sold for human consumption, under the name of "cuchoyuyo". Considerable quantities are collected, the stipe being cut just above the holdfast, the latter being left on the rock. In areas where there is a permanent fishing population with readily accessible *Durvillea*, this harvesting continues throughout the summer, i.e., the growing period. There cannot fail to be some considerable effect on the abundant *Durvillea*. Is this effect great enough to reduce the *Durvillea* from the status of dominant to that of subdominant, or, in extreme cases, even making the species rare? I consider that this is so, especially in view of the fact that *Durvillea* significantly is more common in inaccessible places. The continual harvesting of *Durvillea* has cleared the shore for population by *Lessonia* which, although not as

ideally suited to the exposed coast Infralittoral Fringe as is *Durvillea*, is, nevertheless, able to survive there quite well in the absence of competition from the larger weed. It is significant in this regard that *Lessonia* on exposed coasts tends to consist largely of stipe and holdfast with a few very lateral fronds, whereas specimens of the same species from sheltered places have a small stipe but a large, broad healthy-looking frond. In this case it is likely that there is intense interspecific competition between these two algae, each being slightly more suited to one habitat than the other. I consider that *Lessonia* is the more adaptable species, being found in a greater variety of habitats than the wave action loving *Durvillea*. This is abundantly clear from the field observations, especially since *Durvillea* is absent from sheltered places.

It may not be significant that I did not see any beds of *Macrocystis* in the area Point Curaumilla to Quintero, though there are beds at Las Ventanas and Quintero. The absence of this species may be correlated with a sandy floor along this coastline.

(b) Quintero and Ventanas

These two places are on the coast to the north of Montemar, lat. 32° 45′ S. Although Quintero is about five kilometres from Ventanas, it is convenient to consider them together as one ecological unit. The position of these two places in relation to the prevailing swell is shown in fig. 20.

FIG. 20.—Outline sketch of the Quintero area. The stippled areas show the location of the beds of Macrocystis.

At Ventanas the most salient feature, one which is very different from any conditions seen near Montemar, is the presence of an area of *Macrocystis* which is exposed at low water spring tides. This species, *M. integrifolia* Bory, favours places where there is just less than the maximum wave exposure (Photo 6).

Macrocystis also occurs in beds offshore, the fronds of the plants being visible floating on the surface of the water. These beds are not extensive in area and cannot be considered as forming a continuous breakwater, though they must have some local effect.

The algae of the Infralittoral fringe on the fully exposed coast at Ventanas are *Lessonia* and *Durvillea*. The latter species is fairly common, there being more plants than at Montemar, but it does not reach the status of the dominant alga of the Infralittoral Fringe.

Iridaea is present at Ventanas in the barnacle band, but at Quintero the zonation is slightly changed. The shore at Quintero is more sheltered than any other part of the coast examined. This is especially true of the area on the northern side of Quintero, which is sheltered from the prevailing northerly swell of the headland. In this area *Iridaea* is absent as is *Lessonia* from the very sheltered places. *Porphyra* is very scarce but the barnacle belt is present with a very well developed *Littorina* belt.

Macrocystis does not occur in the sheltered waters but is found in rocky bays suffering just less than maximum exposure. The sandy bay on the exposed side of Quintero, which has rocky outcrops in the Infralittoral, is richly covered with *Macrocystis*.

The principal interest and significance of this area lies in the absence of *Iridaea* from the sheltered coast and the presence of *Macrocystis* in the Infralittoral Fringe on nearly exposed coasts. It is also of not considerable importance to note that on the sheltered coast of Quintero there is no Infralittoral Fringe alga replacing *Lessonia*.

(c) Concon

Concon lies nine kilometres to the north of Montemar.

The Concon bay area (lat. 32° 56′ S.) is of interest because the River Aconcagua enters the sea at this town, and so some estimate can be made of the effect of fresh water on the intertidal zonation. No attempt was made to examine the animals and plants of the fresh water.

The River Aconcagua flows from the Cordillera to the sea and is very seasonal in its volume of flow. In the summer the water entering the sea is all contained in a channel about six metres in width and about three metres deep at its deepest point. However, in winter and during the melting of the snows on the mountains the river becomes greatly swollen and is almost one kilometre in width.

The flow from the river enters a broad bay at its southern end. The shoreline of all of the northern part of the bay is composed of sandy beaches. To the south between Concon and Montemar there are rocks and cliffs, and it is on these rocks near the River Aconcagua that the examination was carried out.

The rocks nearest the river mouth are devoid of all forms of macroscopic life. The first zonal organism encountered is *Enteromorpha intestinalis* (L.) Link. This alga forms a green covering over most of the rocks which are just outside the mouth of the river. The rocks in this area are fine-grained sandstone, but this type of substratum alters after a few metres to the typical rocks of the area, namely, granite pierced by dolerite dykes.

The first evidence of truly marine forms occurs halfway between a bridge, La Calletilla, and the mouth of the river. At this place, *Porphyra columbina* occurs. Barnacle tests without living animals are very frequent on this part of the shore. It is probable that the barnacles were all killed during very heavy flooding by the river during the winter of 1954.

The first living barnacles occur about six metres further along the shore from La Calletilla. The majority of the barnacles are dead but there are a few living specimens. The live specimens are of about the same size as the dead tests. This may indicate that they are of the same year group and, therefore, survivors of the 1954 flood or, on the other hand, they may be of a different year group and no similar conclusion can be drawn.

Some 10 metres from the first appearance of barnacles, the facies becomes decidely marine, with the sudden appearance of *Iridaea laminarioides, Brachidontes purpuratus, Siphonaria laeviuscula* Sow. and the proportion of live barnacles increases very greatly.

An examination carried out a further 10 metres along the shore shows that nearly all the barnacles are living, and that the mussels have become very numerous and extend down into the Infralittoral Fringe, forming dense sheets covering the rocks. *Porphyra* is very plentiful and the grapsid crab, *Leptograpsus variegatus*, is first seen here. *Littorina peruviana* is common on sun-sheltered rocks, and *Corallina chilensis* appears hereabouts in rock pools but not as a belt-forming species.

Lessonia first appears just to the south of a small prominence, also *Acanthopleura echinata*, "Lithothamnia", *Turbo niger* and *Centroceras clavulatum*. The cling fish *Sicyases sanguineus* is also noted to be here. In some places *Littorina peruviana* is sufficiently numerous to form a distinct band in the upper parts of the barnacle belt.

The Littorinids hereabouts are of two species. The most common is *L. peruviana* (= *L. zebra*), but *L. araucana* d'Orb. is also frequent, being larger in size and occurring slightly higher on the shore than *L. peruviana*.

10. DISCUSSION

At this stage I do not propose to discuss the distribution, habits and general biology of any of the non belt-forming species. This will be dealt with in a later contribution, but here I will confine myself to a few general remarks concerning the zonally-significant species.

One of the most surprising features at Montemar is the absence of a Supralittoral Fringe in the immediate vicinity of the Estacion de Biologia Marina. This has been attributed to a combination of excessive nitrogenation, combined with an immersion factor which does not permit the development of a characteristic fringe of Littorinids. *Littorina peruviana* occurs within the barnacle belt and does not form the characteristic strip above the barnacles. This feature is not only confined to Montemar but also is found at all other parts of the neighbouring coast with the exception of near the Rio Aconcagua where *L. araucana* is the dominant species and forms a well-developed band above the barnacles. The top of the barnacle belt is dominated by *Chthamalus cirratus*. This species is known from Peru to Chiloë Island (Darwin, 1854, and Pilsbury, 1910). *Chthamalus cirratus* extends as far down the shore as the Infralittoral Fringe, being collected on *Balanus psittacus* by Coker. The lower part of the *Chthamalus* belt also has individuals of *Chth. scabrosus* Darwin. This species was recorded by Darwin as often with *Chth. cirratus* and *Balanus flosculus*. The latter species is the more common barnacle on the lower part of the shore, being found on *Concholepas, Brachidontes*, on *Mytilus*, rocks or on *Balanus psittacus*. *Chth. scabrosus* is more common at the lower shore levels with *B. flosculus* than with *Chth. cirratus*. The lower part of the belt is also occupied by three other barnacles, *Balanus laevis* Bruguiere, *B. psittacus* (Molina), *Verruca laevigata* Sowerby. *B. psittacus* is the most conspicuous of these, being the largest of the family. I measured a specimen 18 cms. in height and Darwin records the species as being "more than nine inches in length". It is of interest that he doesn't record the species as intertidal. Darwin noted *B. psittacus* adhering to *Concholepas*, but I did not see any such association.

The character of the zonal organisms changes at the bottom of the *Chthamalus* belt, algae becoming the dominant organisms. *Iridaea* is generally distributed throughout the Montemar area, except in places with strong sand scouring and this, in turn, is replaced by a mixed algal association, in turn yielding to the large brown *Lessonia* of the Infralittoral Fringe. *Iridaea, Centroceras* and *Gelidium* all utilise mussels of either of the genera *Mytilus* or *Brachidontes* as a substratum, *Brachidontes* being found at a slightly higher level on the shore than *Mytilus*. I am not sure of the permanence of the mussel beds as a zonal feature at any one place. I have found in Tasmania that the mussel beds at any one place change in extent from time to time and even may be absent for short periods. However, it is important to note that mussels, particularly *Brachidontes*, are of considerable ecological significance in this region, since the presence of these organisms on exposed coasts has been found to be of biogeographical importance elsewhere (Bennett and Pope, 1953).

The influence of wave action on the vertical distribution of organisms is shown in fig. 18. Several authors have investigated this problem, notably Burrows, Conway, Lodge and Powell (1954). These authors investigated the Law of Widar Brenner (Du Reitz, 1940), which states that the high-water line of the sheltered shore has its ecological equivalent on the exposed shore, not in the high-water line of the exposed shore, but in the upper limits of the reach of the storm waves.

Burrows, *et al*, found that the absence of a climatic factor limited the applicability of the Law because they found that the fogs and mist of Fair Isle assisted the upward extension of the limits of the algae. They go further and point out that the wetting power of a wave is dependent upon the drying power of the atmosphere. In warmer climates than Fair Isle an important part of the drying power of the atmosphere must be the heat of the substratum, for example, at Montemar, during the summer, spray deposited on the shore evaporates very rapidly, almost as soon as it is deposited.

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Photo 1.—*Chthamalus cirratus* belt on the exposed coast at Montemar, February, 1955.

Photo 2.—*Littorina* on a spray-soaked, sun-exposed rock, Montemar, January, 1955. Note the absence of a barnacle belt in this area.

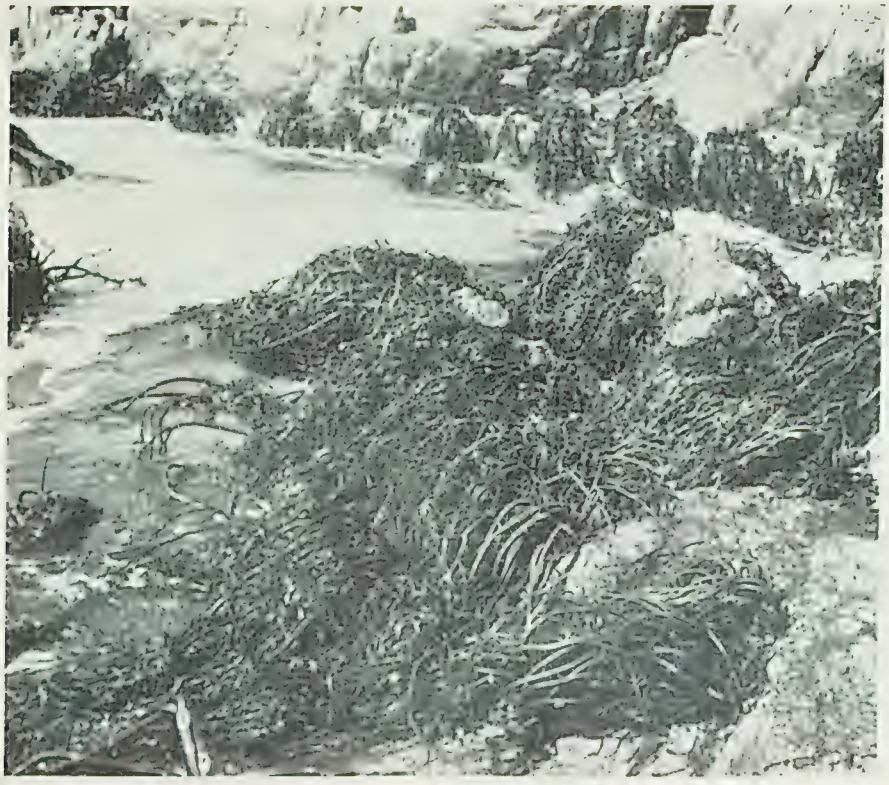

Photo 3.—The Infralittoral Fringe near Montemar, March, 1955. The *Lessonia* plant in the foreground shows the typical scars caused by the limpet *Scurria*.

Photo 4.—*Durvillea antarctica* at Montemar, January, 1955.

Photo 5.—The sheltered coast form of *Lessonia nigrescens* at Laguna Verde, March, 1955.

Photo 6.—*Macrocystis integrifolia* at Las Ventanas, February, 1955.

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